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(54) **HEAT EXCHANGER FOR STEAM GENERATOR AND STEAM GENERATOR COMPRISING SAME**

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CPC ***F28F 13/06*** (2013.01); ***F28D 9/0037*** (2013.01); ***F28F 3/048*** (2013.01); ***F28F 9/026*** (2013.01);
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(57) **ABSTRACT**

A heat exchanger for a steam generator according to one embodiment of the present invention comprises a plate and channels formed on the plate by an photo-chemical etching method, wherein the channels comprise: a primary heat transmission section formed in a manner of having a bent or curved flow path so as to be extended longer than the length at which one side and the other side are connected in a
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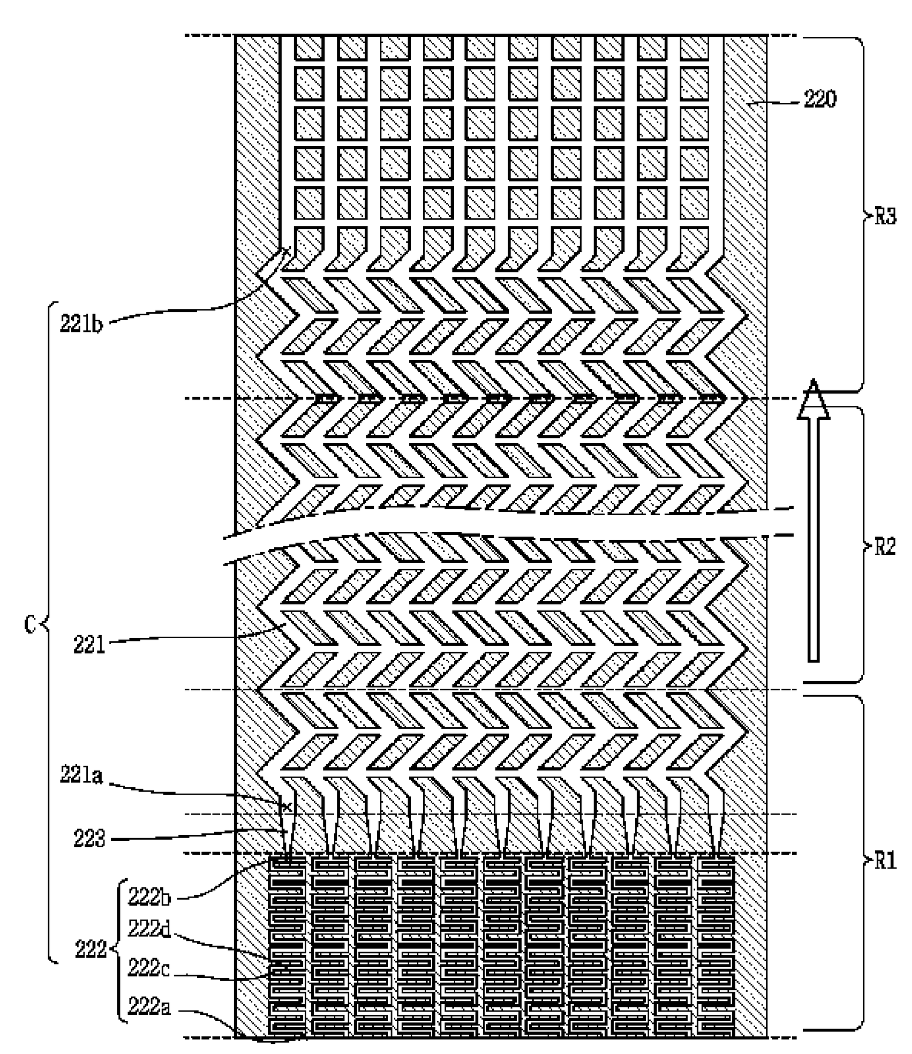

straight line; and a flow path resistance section, formed having a smaller width than the width of the channels formed on the primary heat transmission section and being connected to the one side of the primary transmission section in a manner of having a bent or curved flow path so as to be extended longer than the length at which an inlet and an outlet are connected in a straight line.

10 Claims, 21 Drawing Sheets

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F28F 3/04 (2006.01)
F28F 9/02 (2006.01)
F28D 9/00 (2006.01)
F28D 21/00 (2006.01)

(52) **U.S. Cl.**
CPC *F28D 2021/0064* (2013.01); *F28D 2021/0085* (2013.01)

(58) **Field of Classification Search**
USPC 165/146
See application file for complete search history.

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FIG. 1

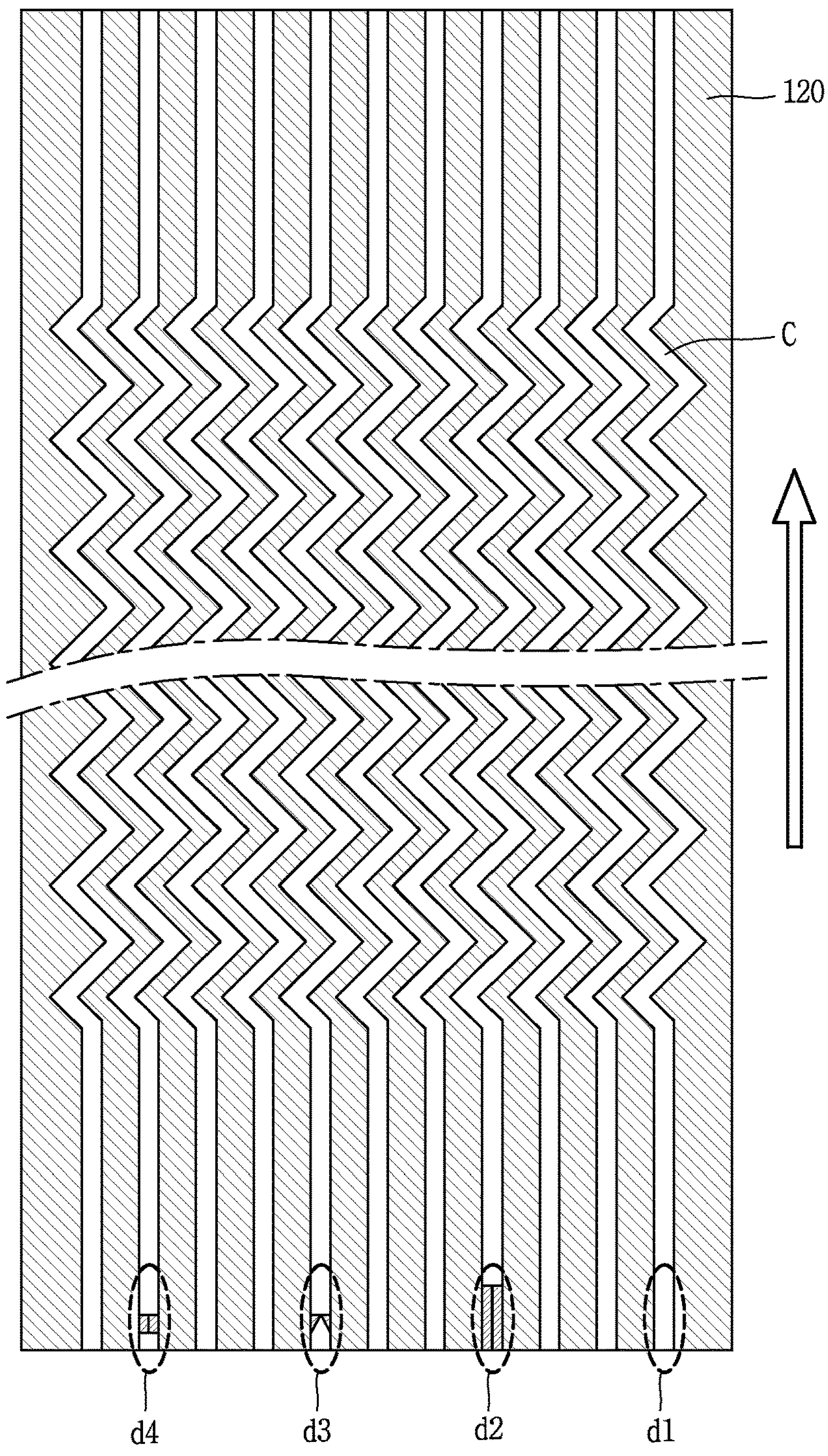


FIG. 2

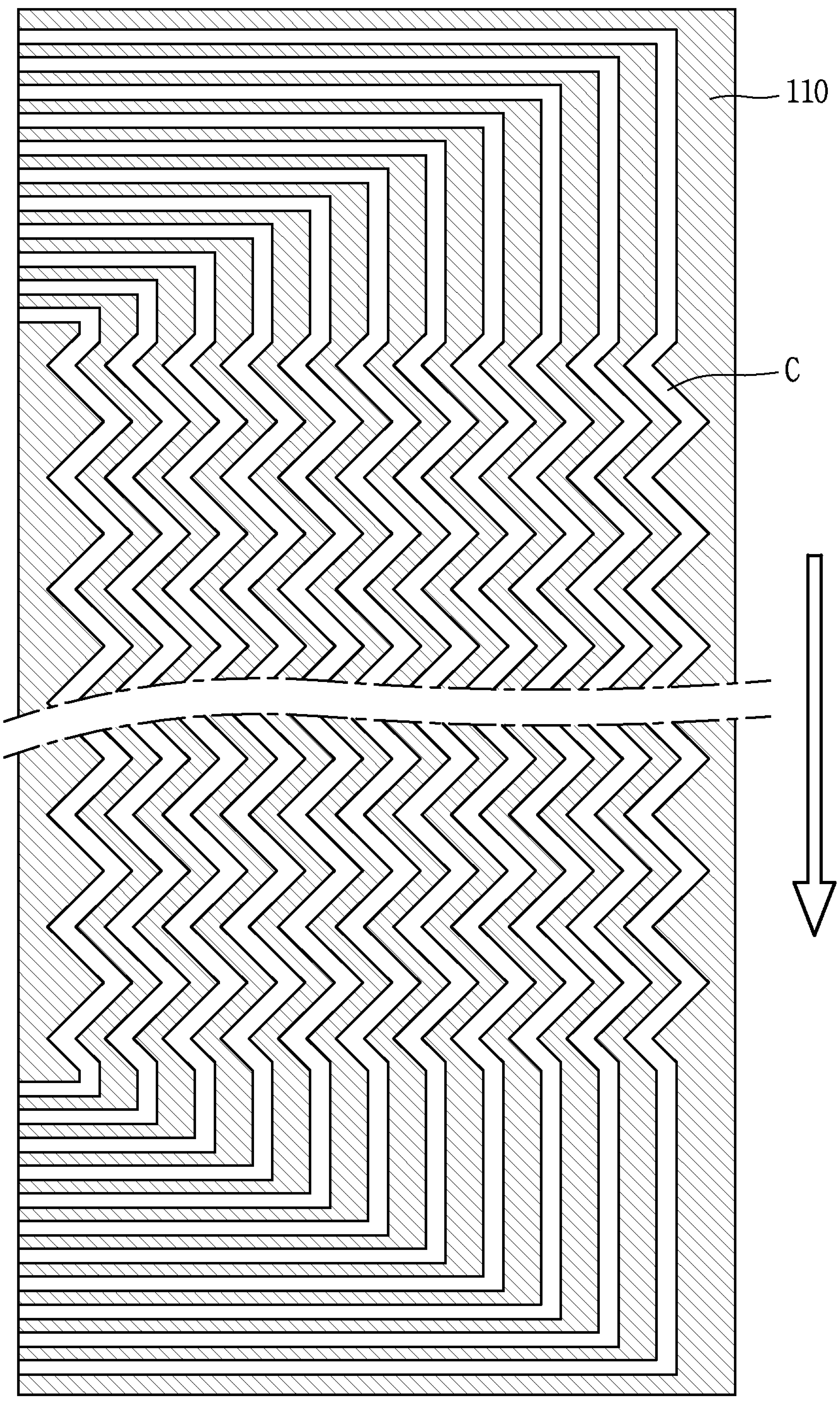


FIG. 3

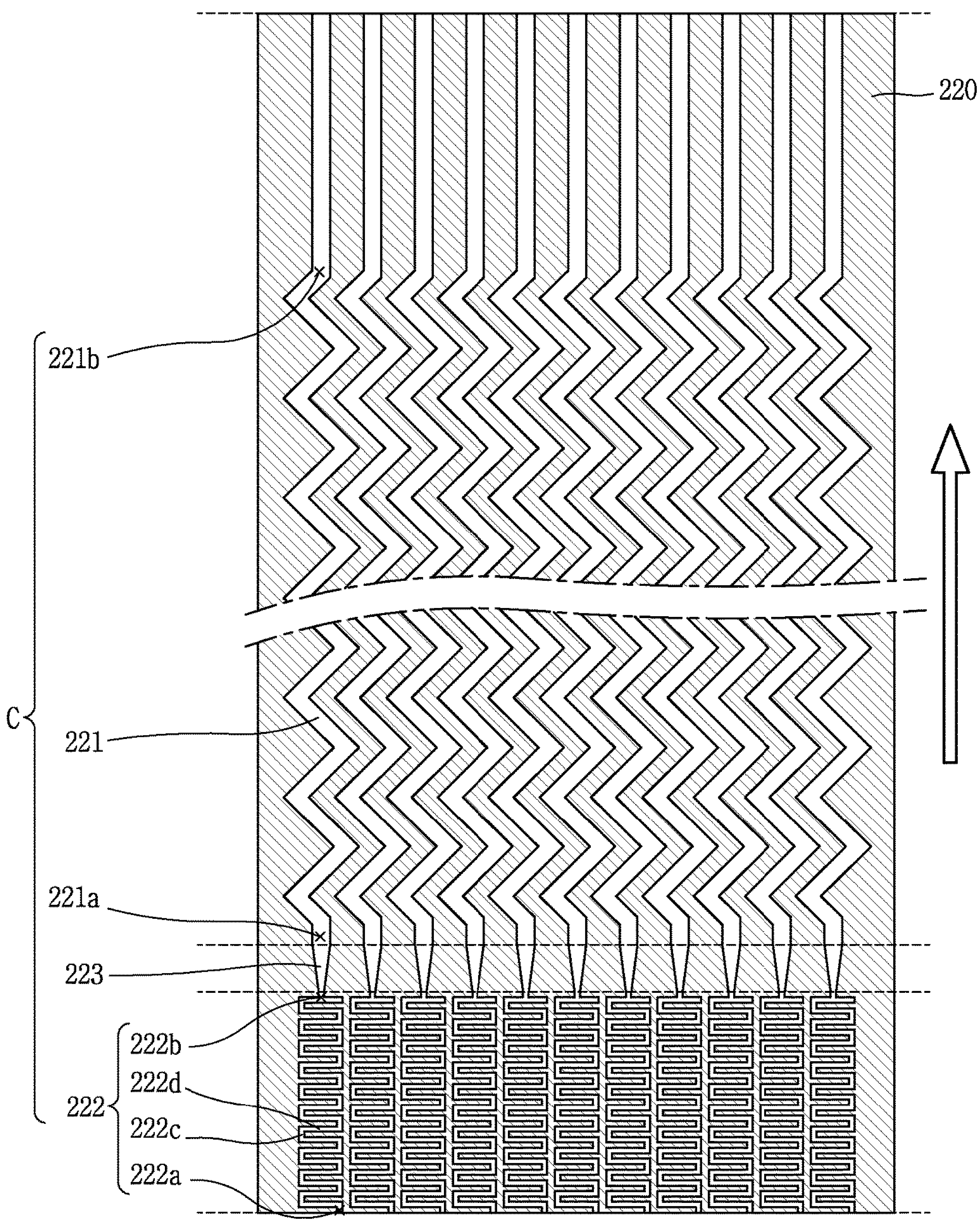


FIG. 4

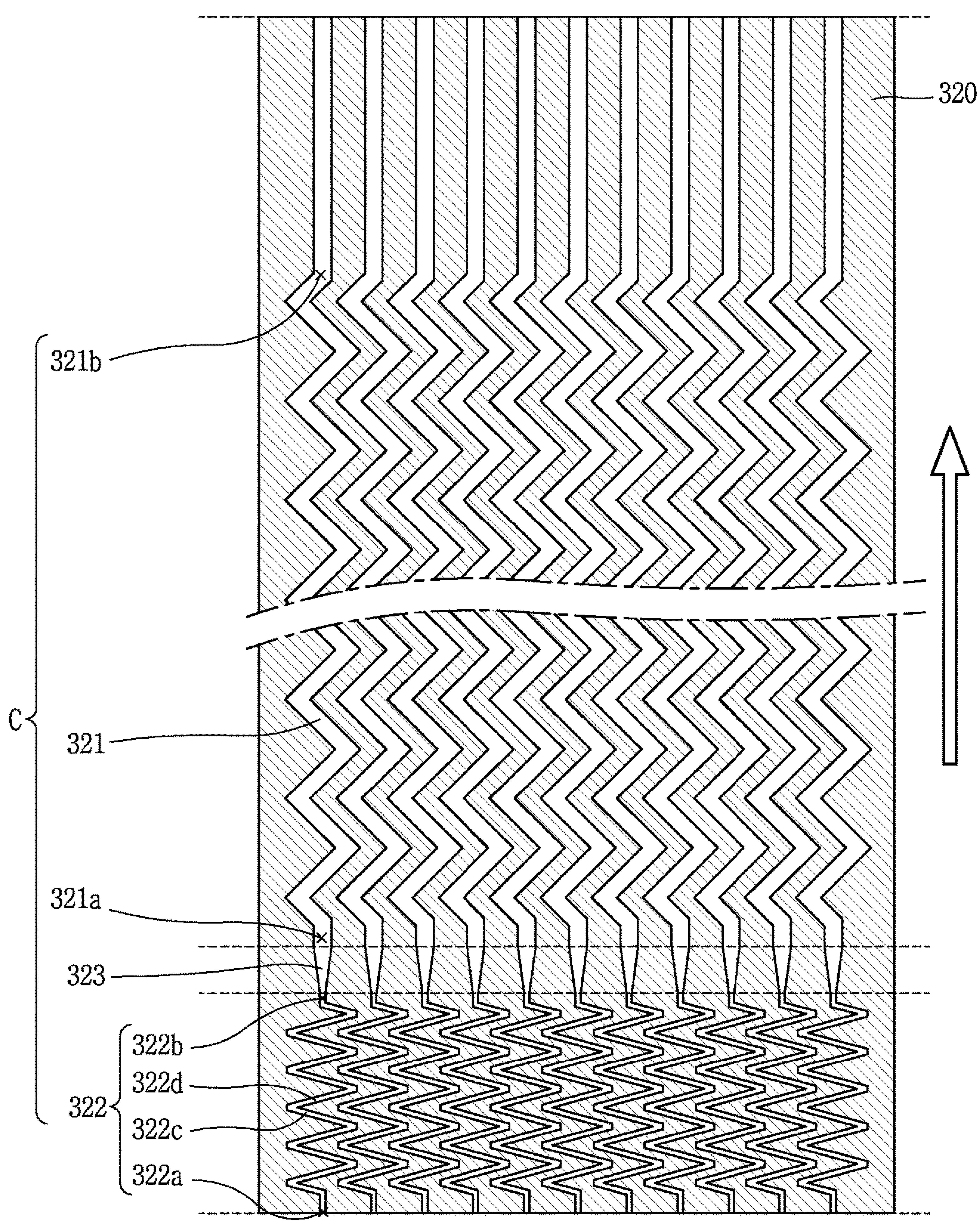


FIG. 5

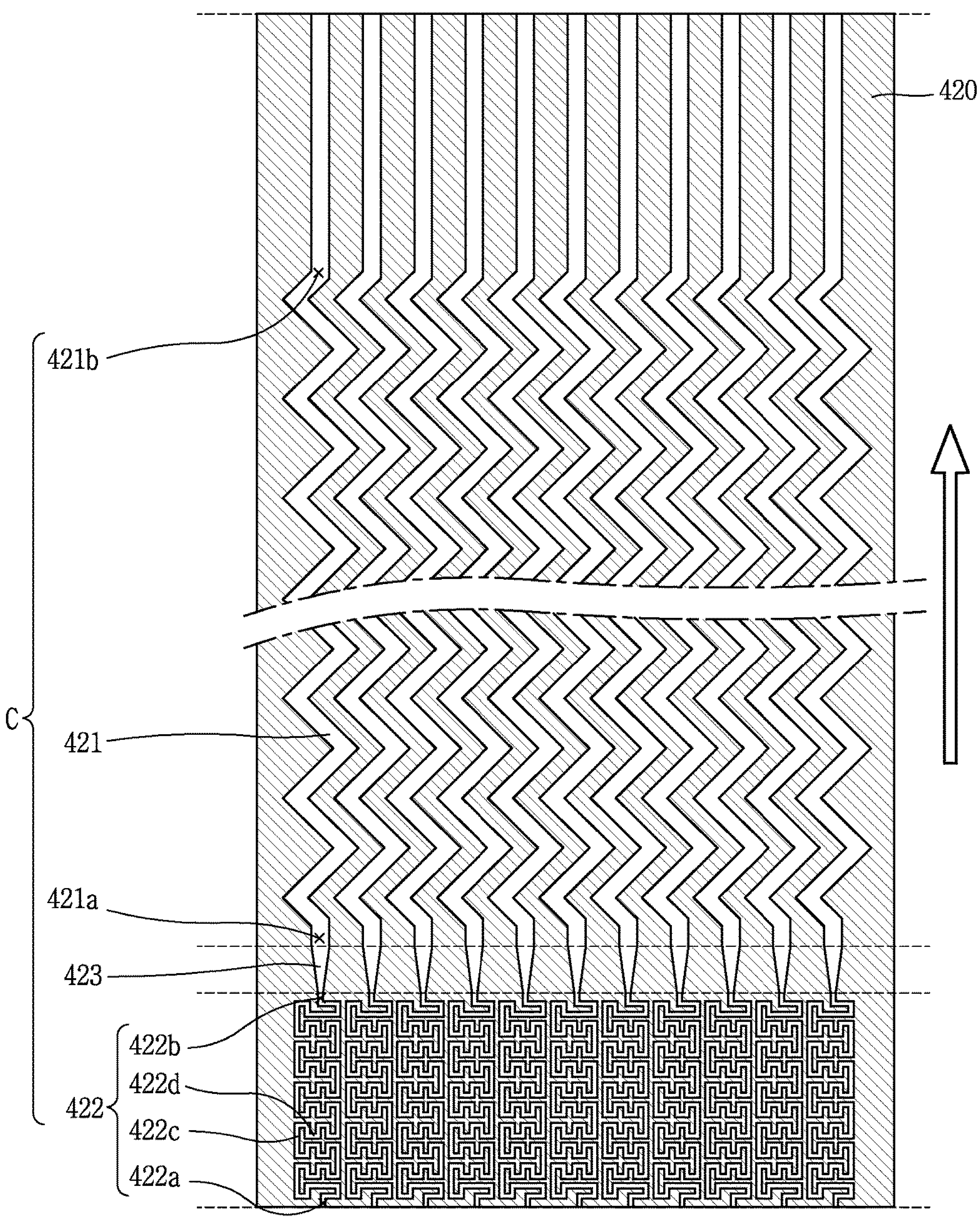


FIG. 6

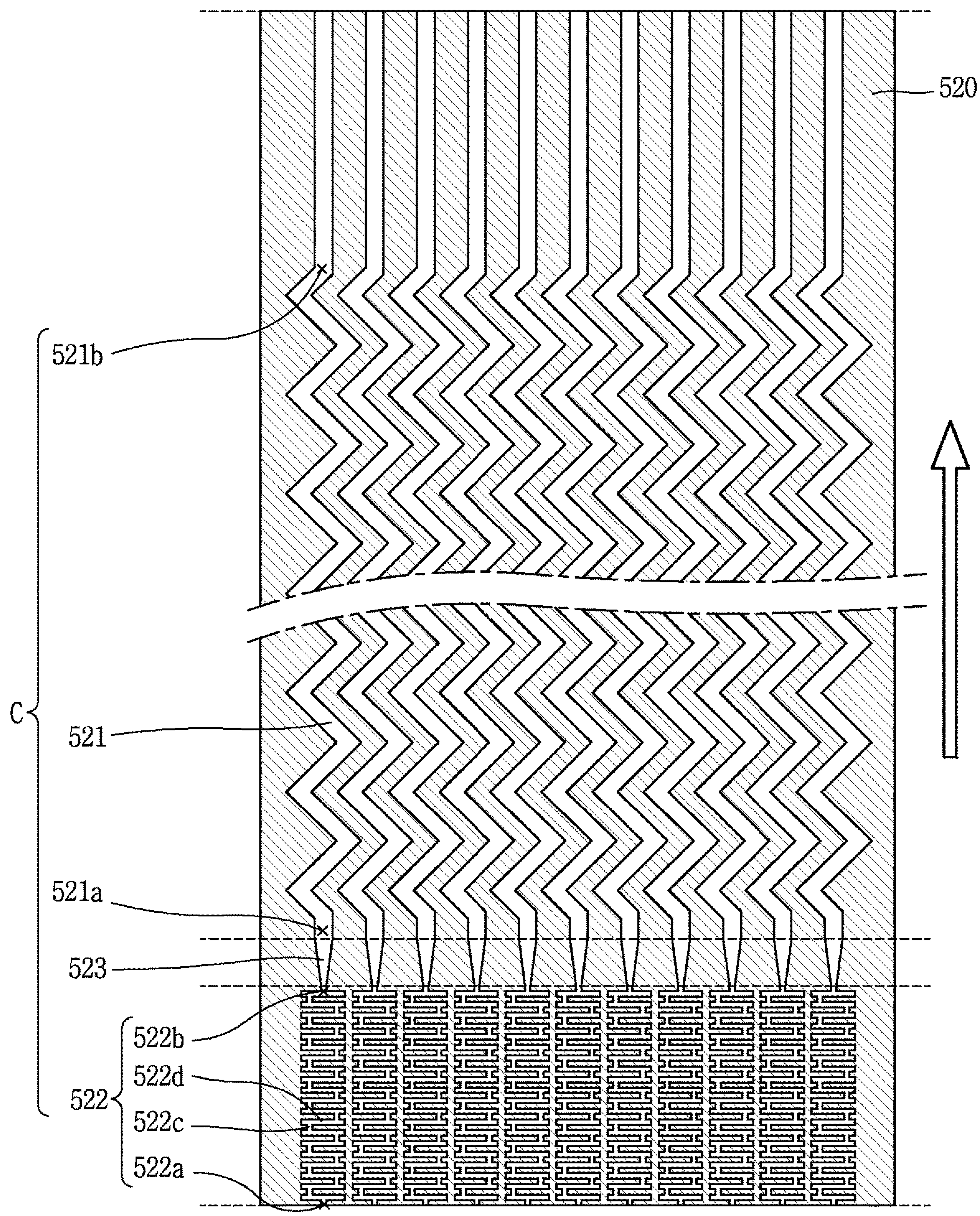


FIG. 7

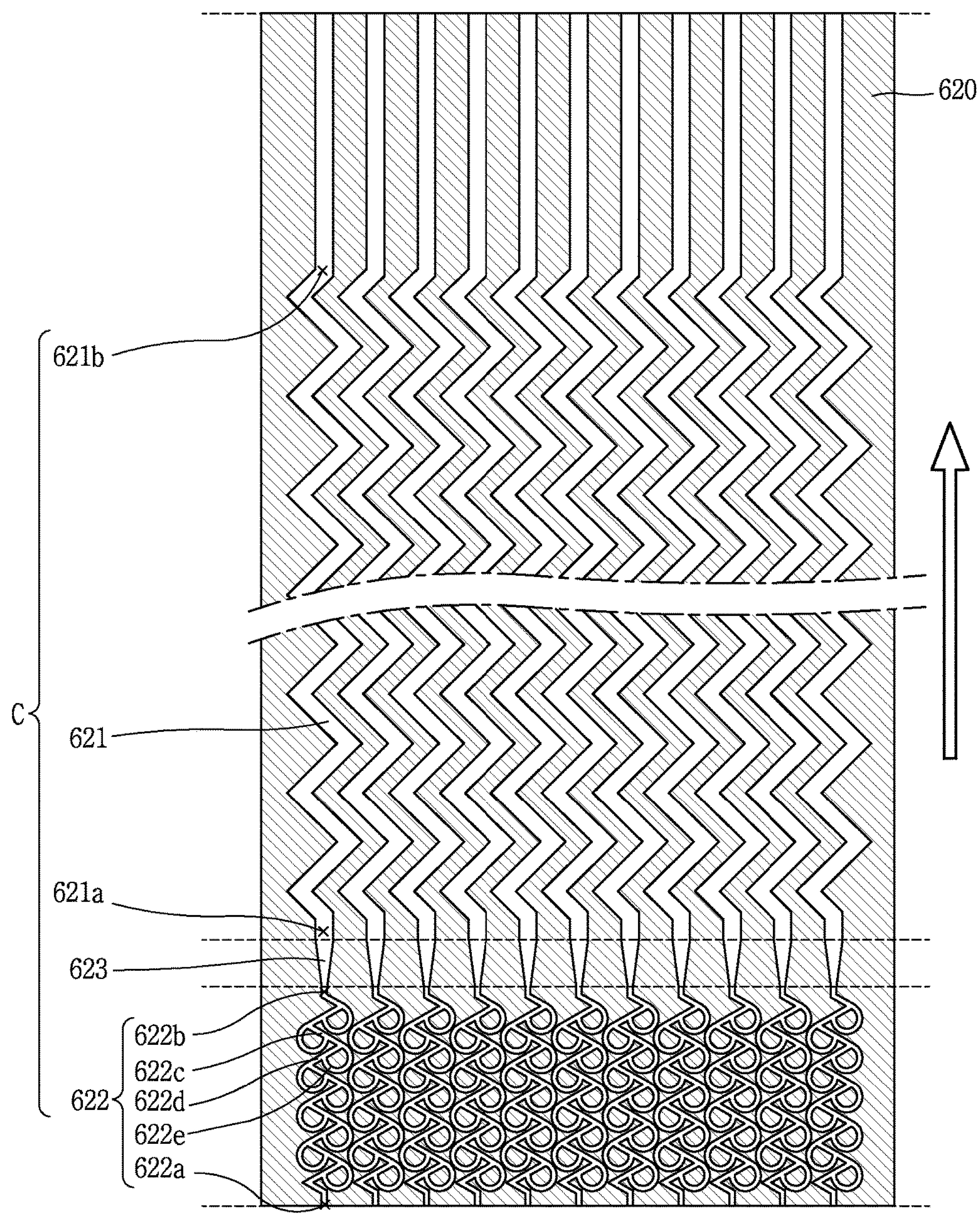
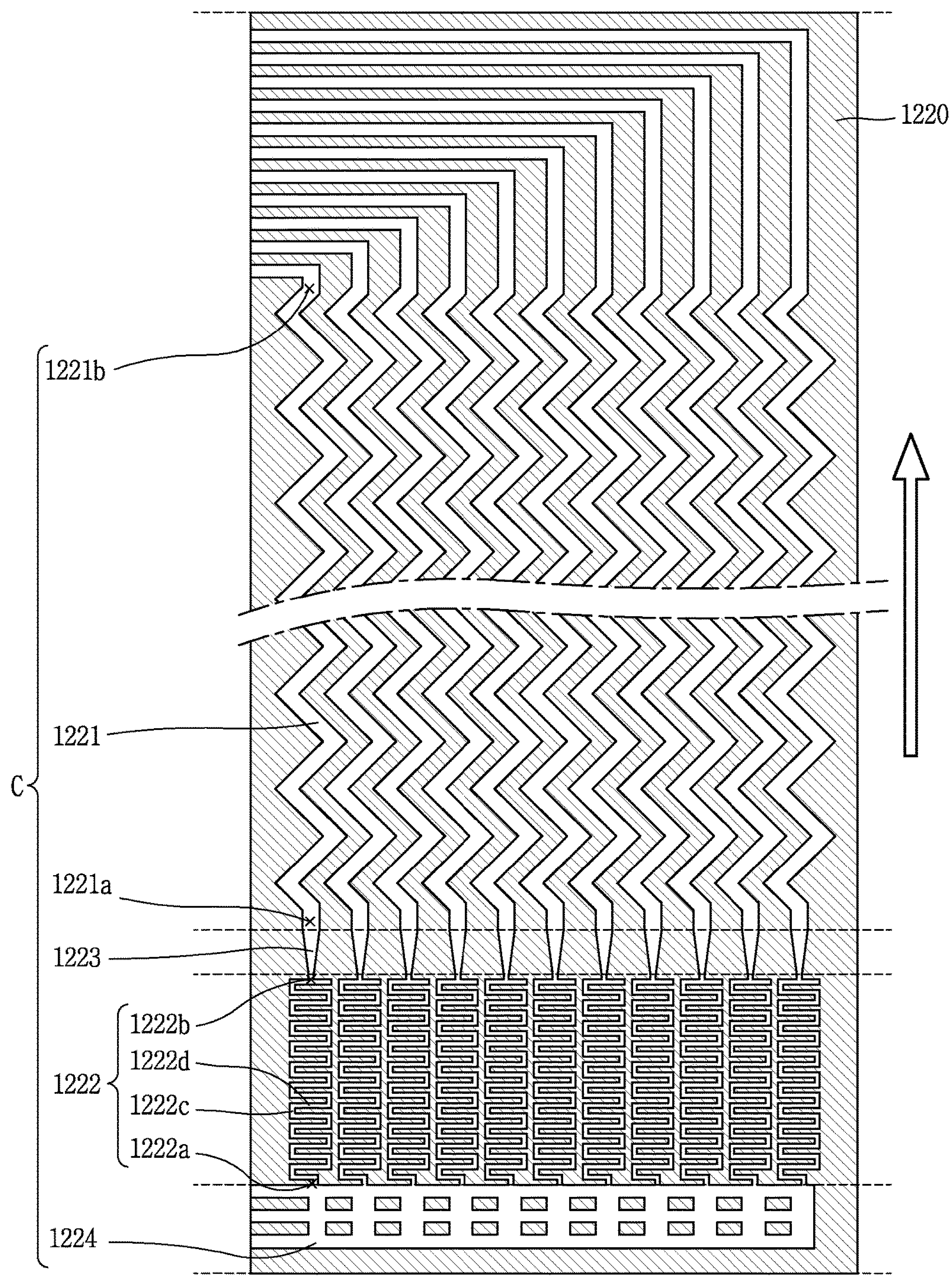


FIG. 8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1221
C
1221a
1223
1222b
1222d
1222
1222c
1222a
1224

FIG. 9

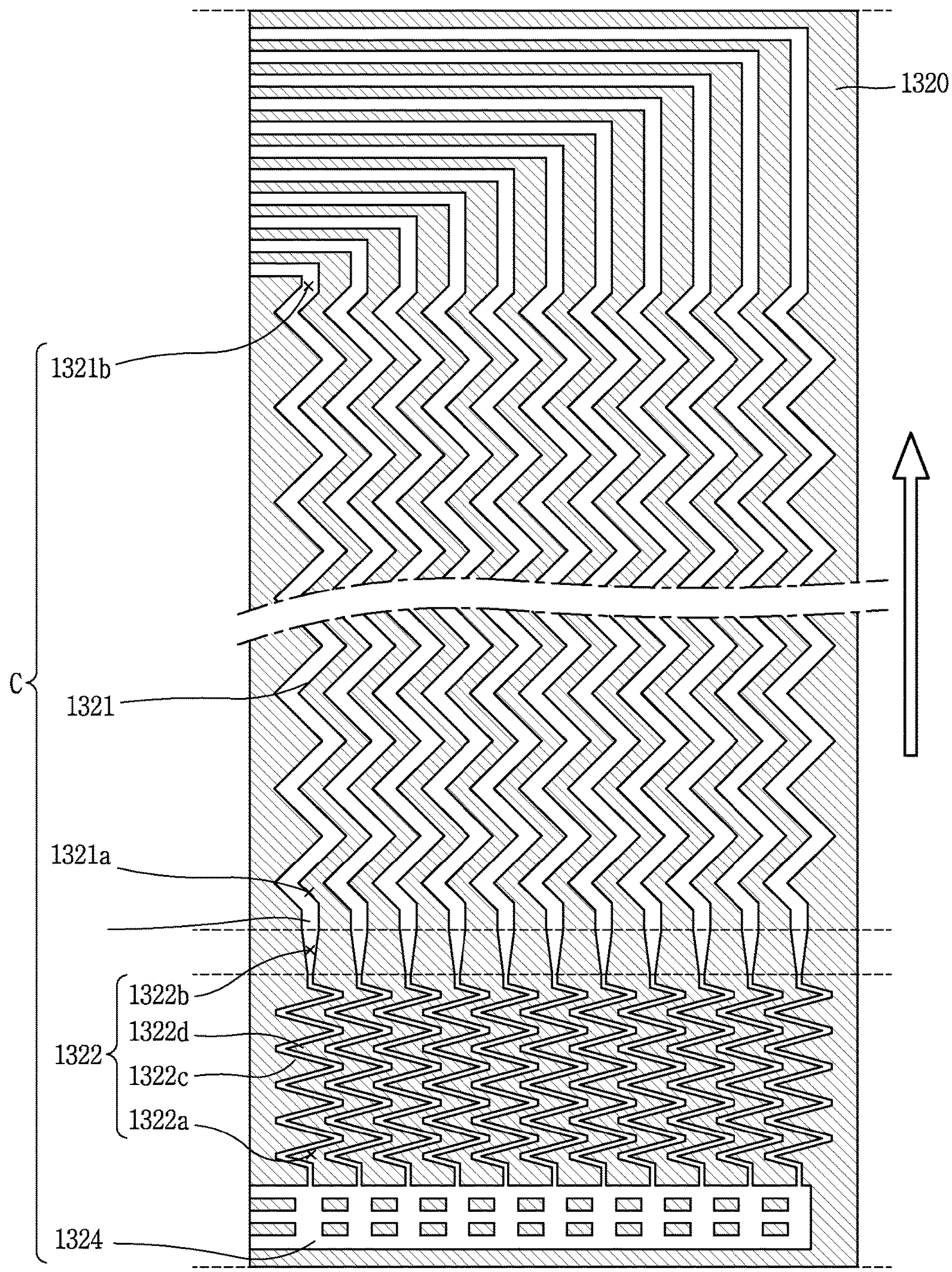
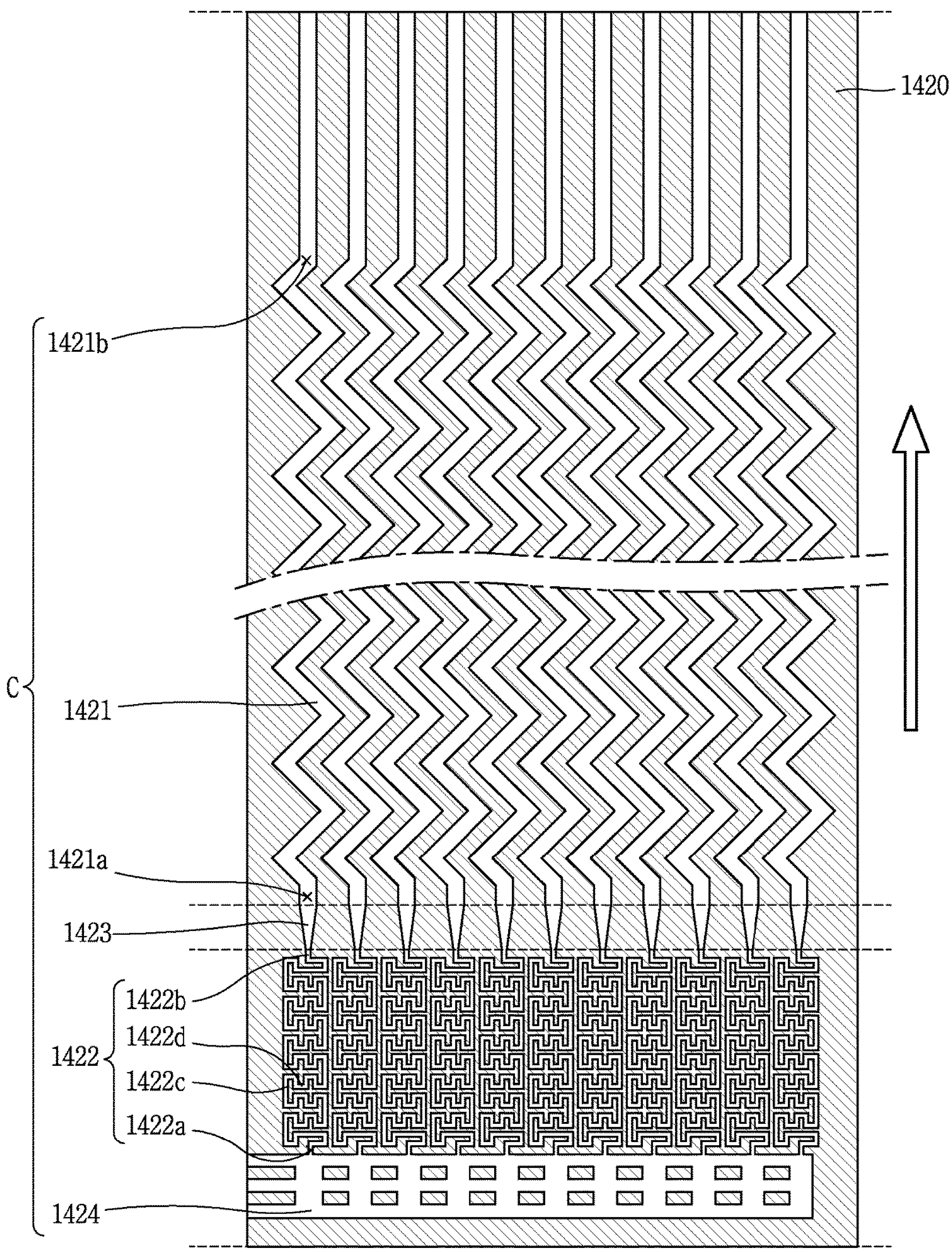


FIG. 10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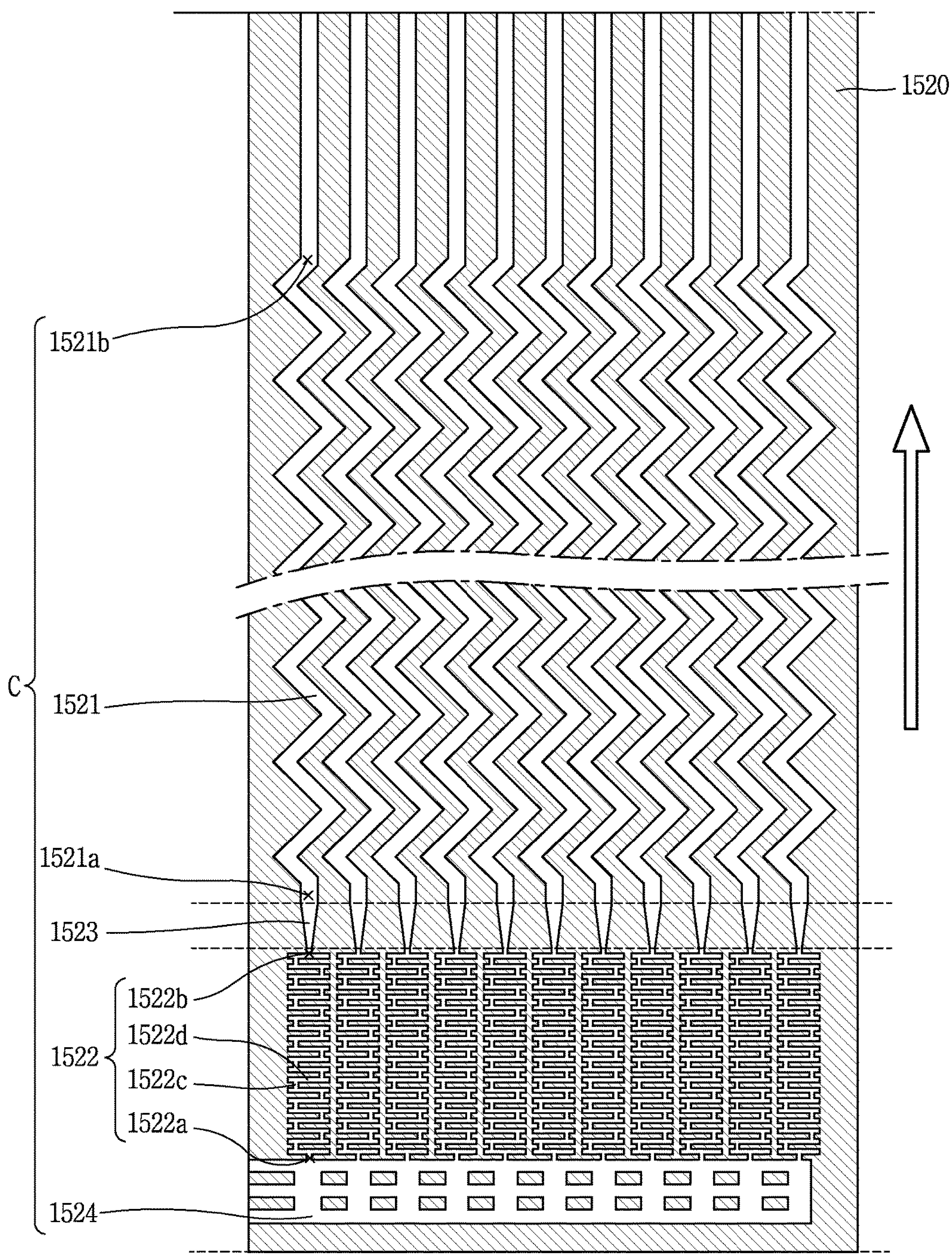
1421
1421a
1423
1422b
1422d
1422
1422c
1422a
1424

FIG. 11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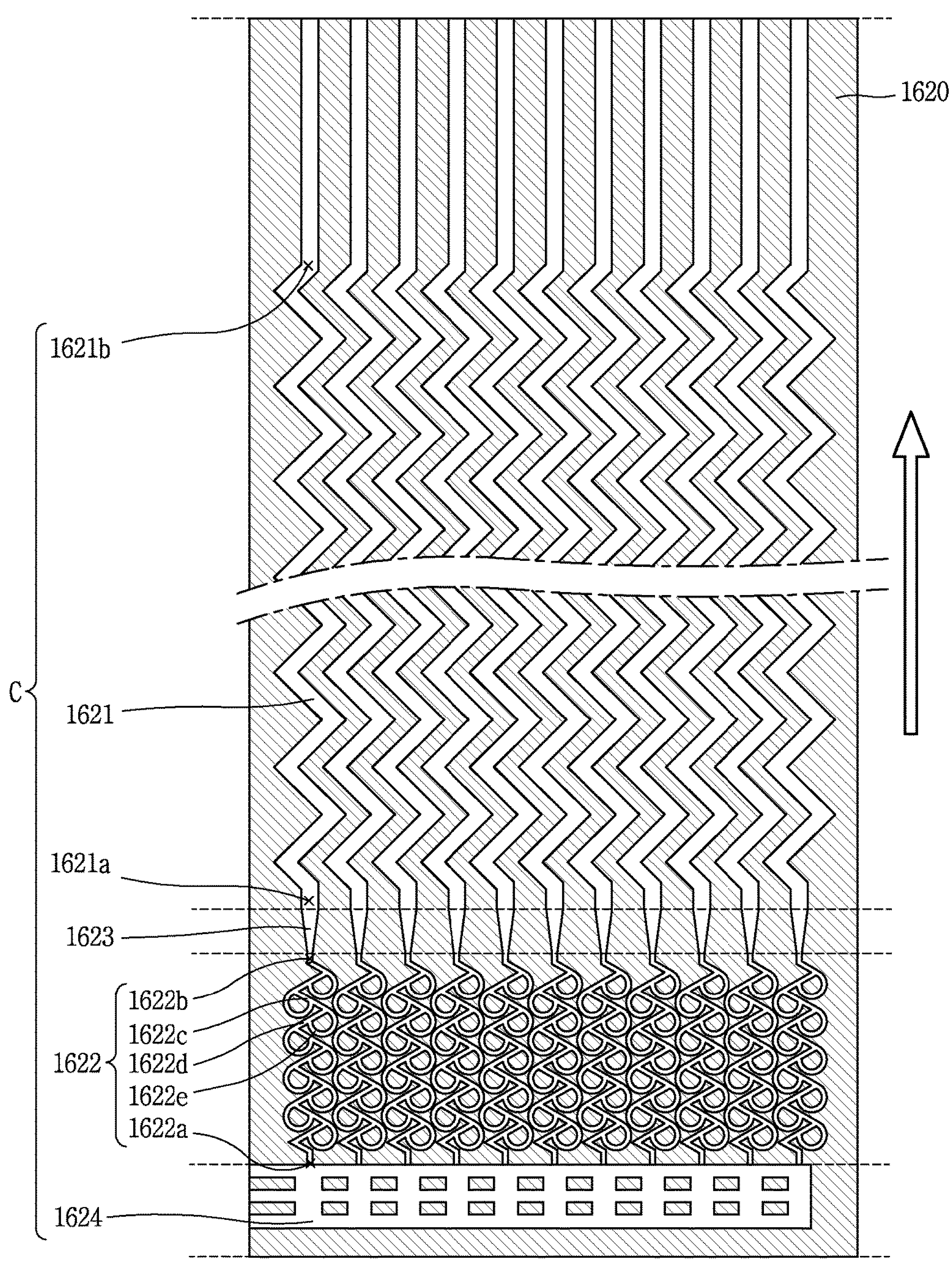
1521b
C
1521
1521a
1523
1522b
1522d
1522
1522c
1522a
1524

FIG. 12



1620
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C
1621
1621a
1623
1622
1622b
1622c
1622d
1622e
1622a
1624

FIG. 13A

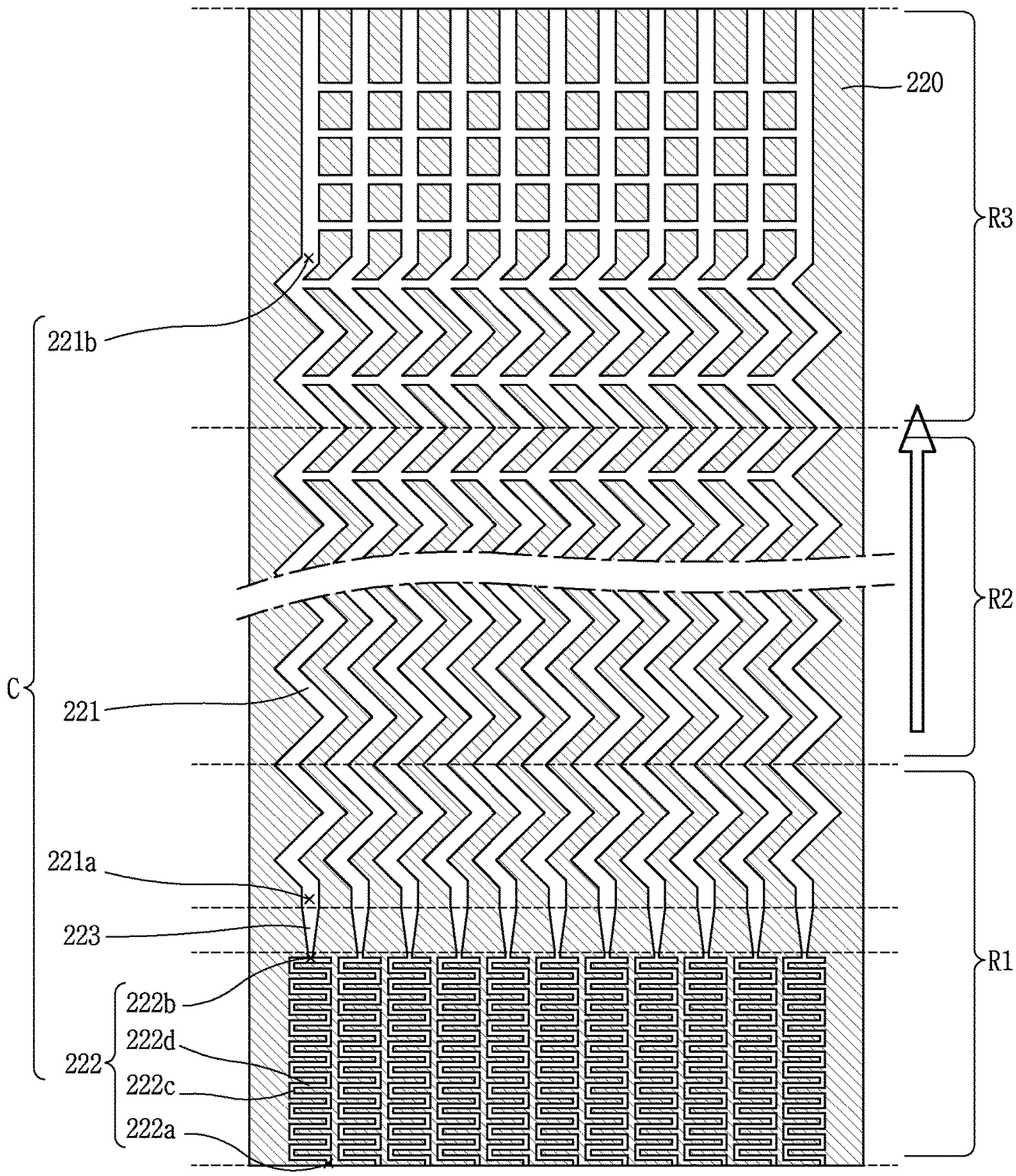


FIG. 13B

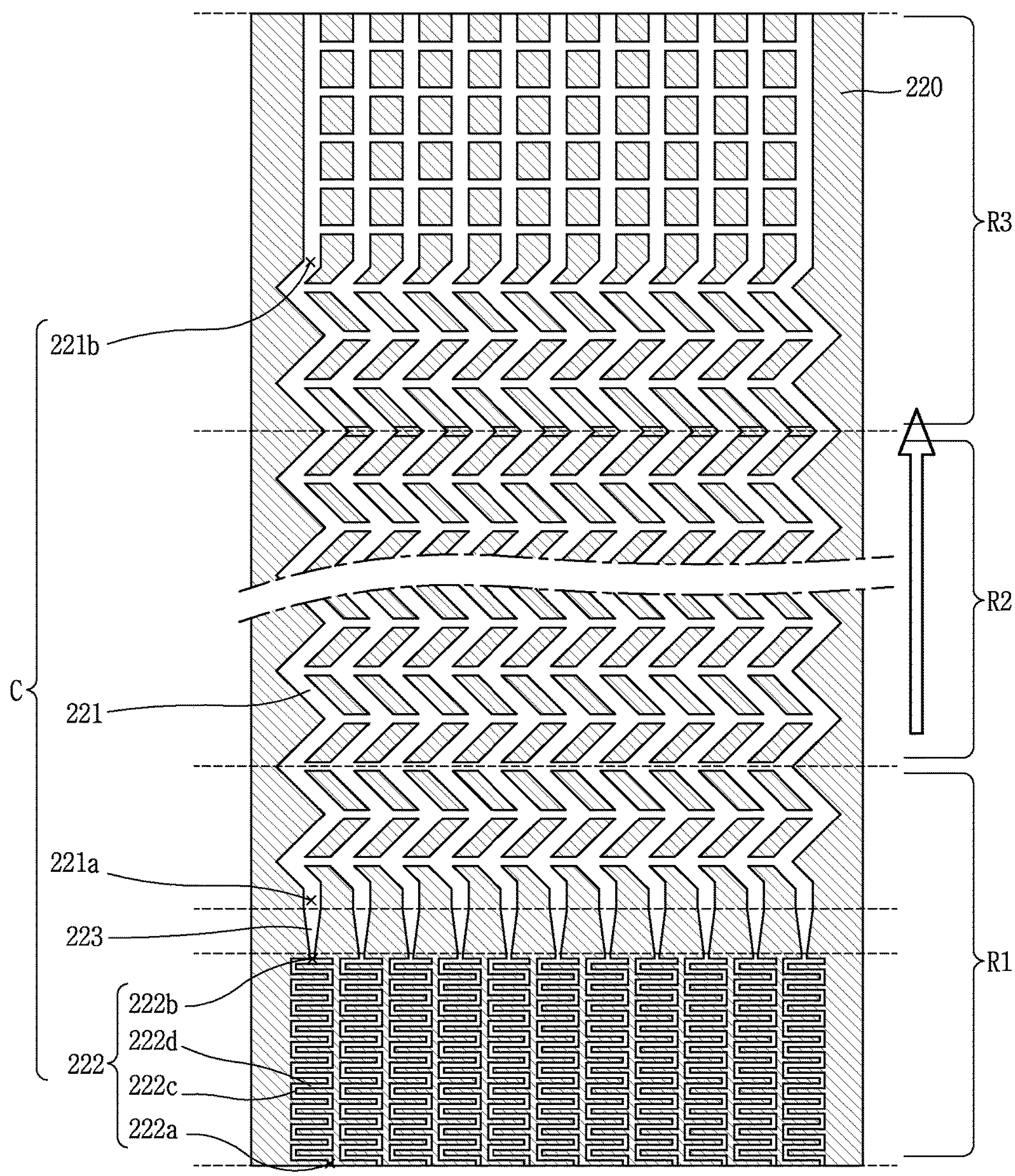


FIG. 14

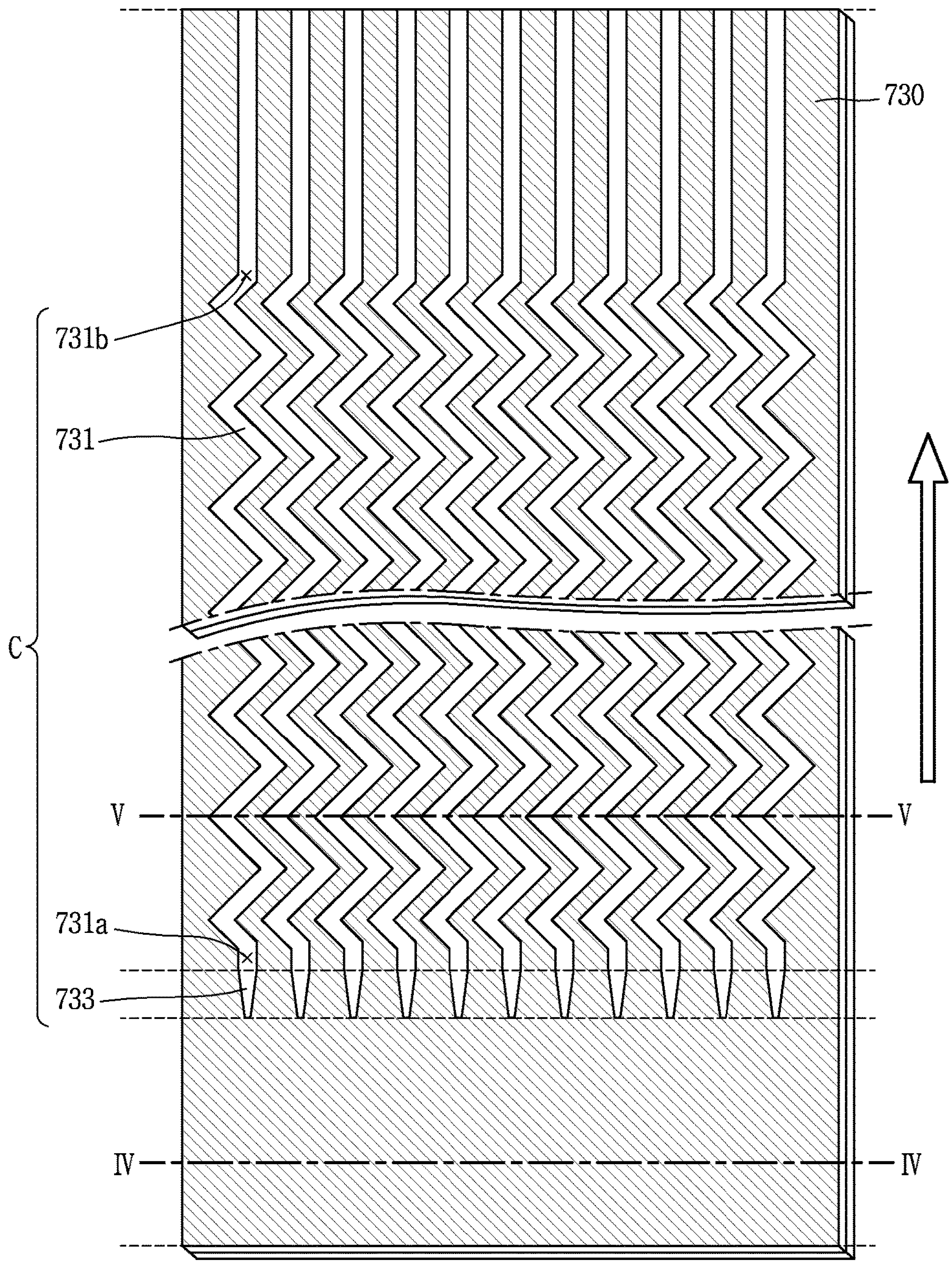


FIG. 15

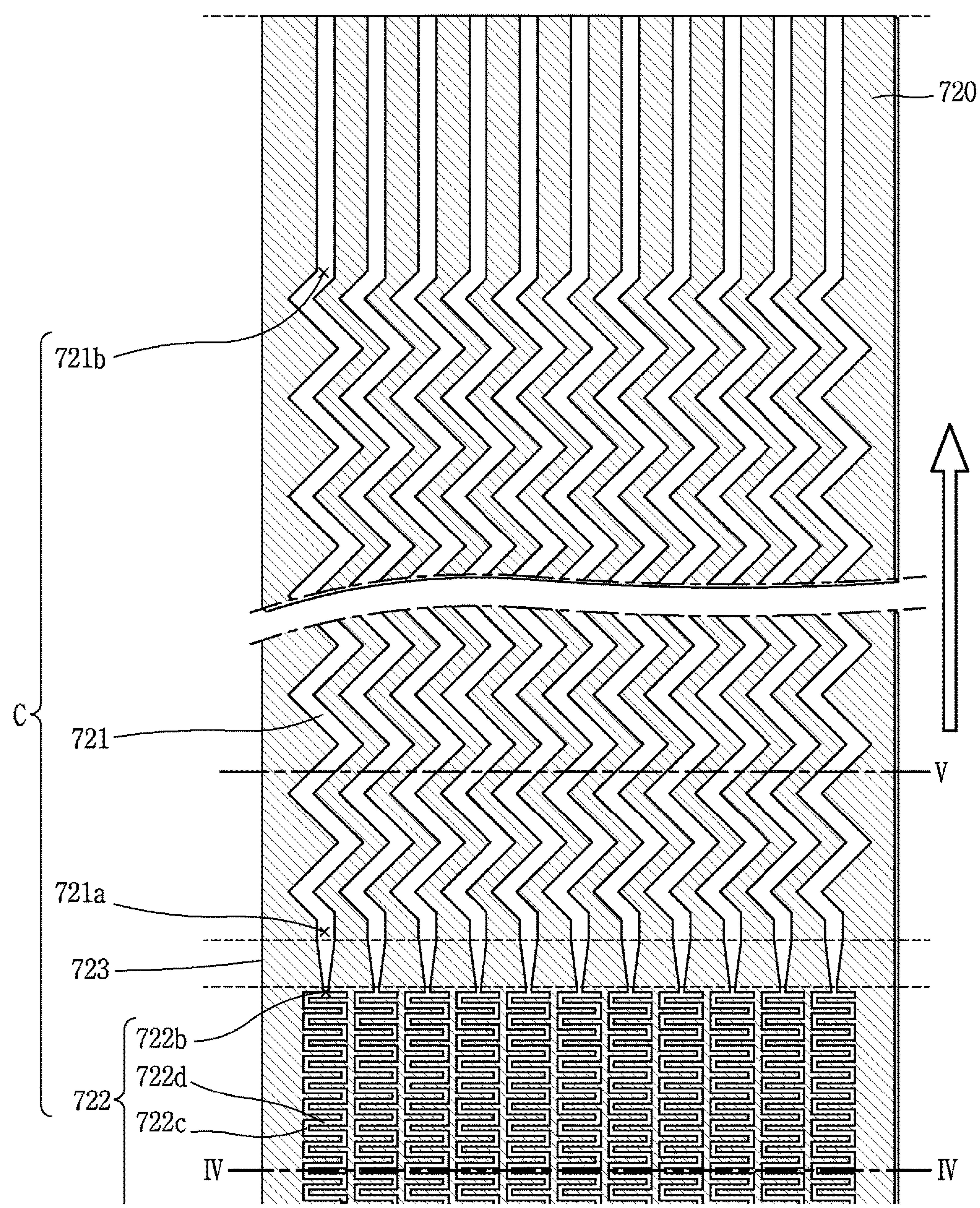


FIG. 16

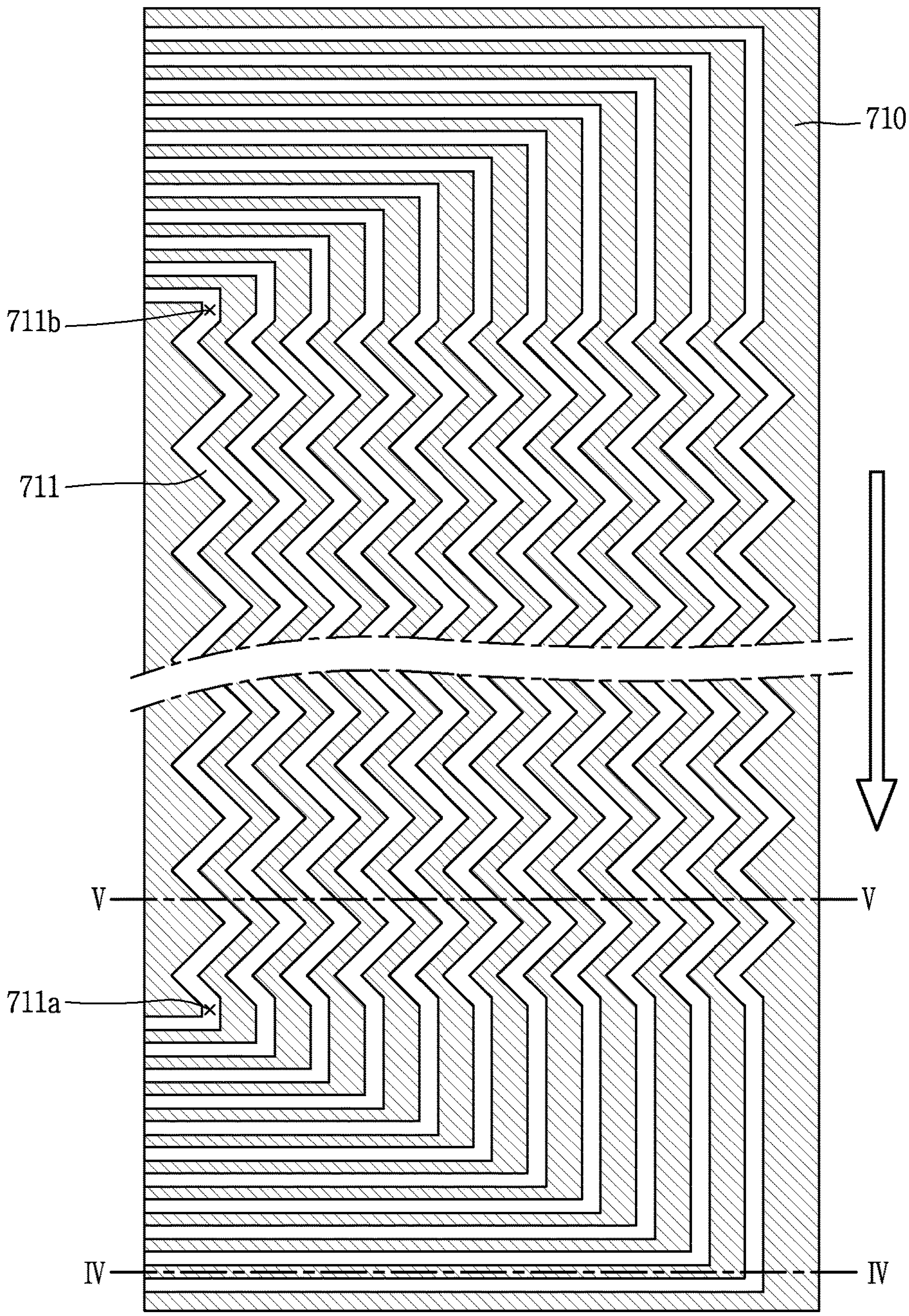


FIG. 17

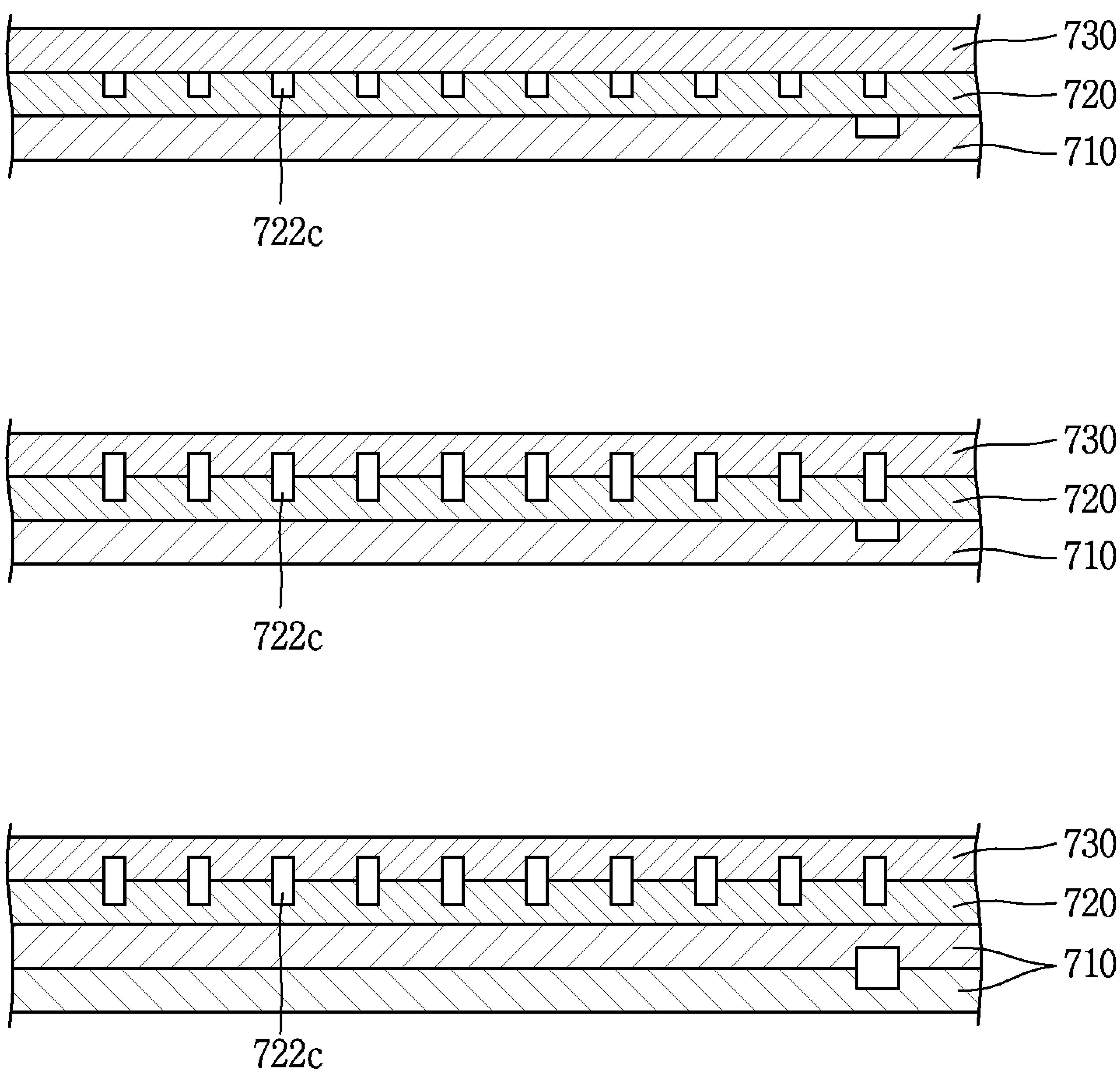
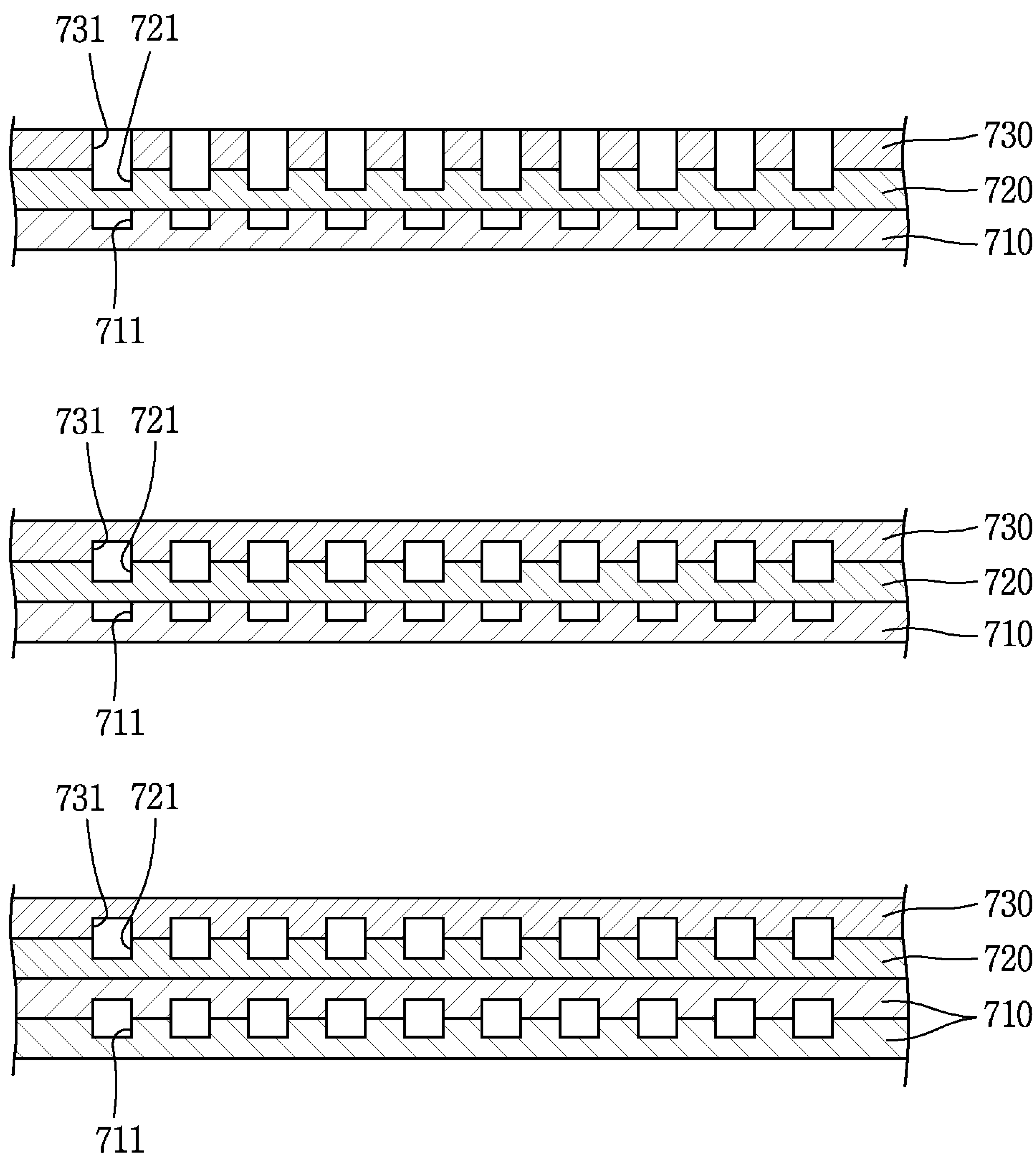


FIG. 18


731
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711

FIG. 19

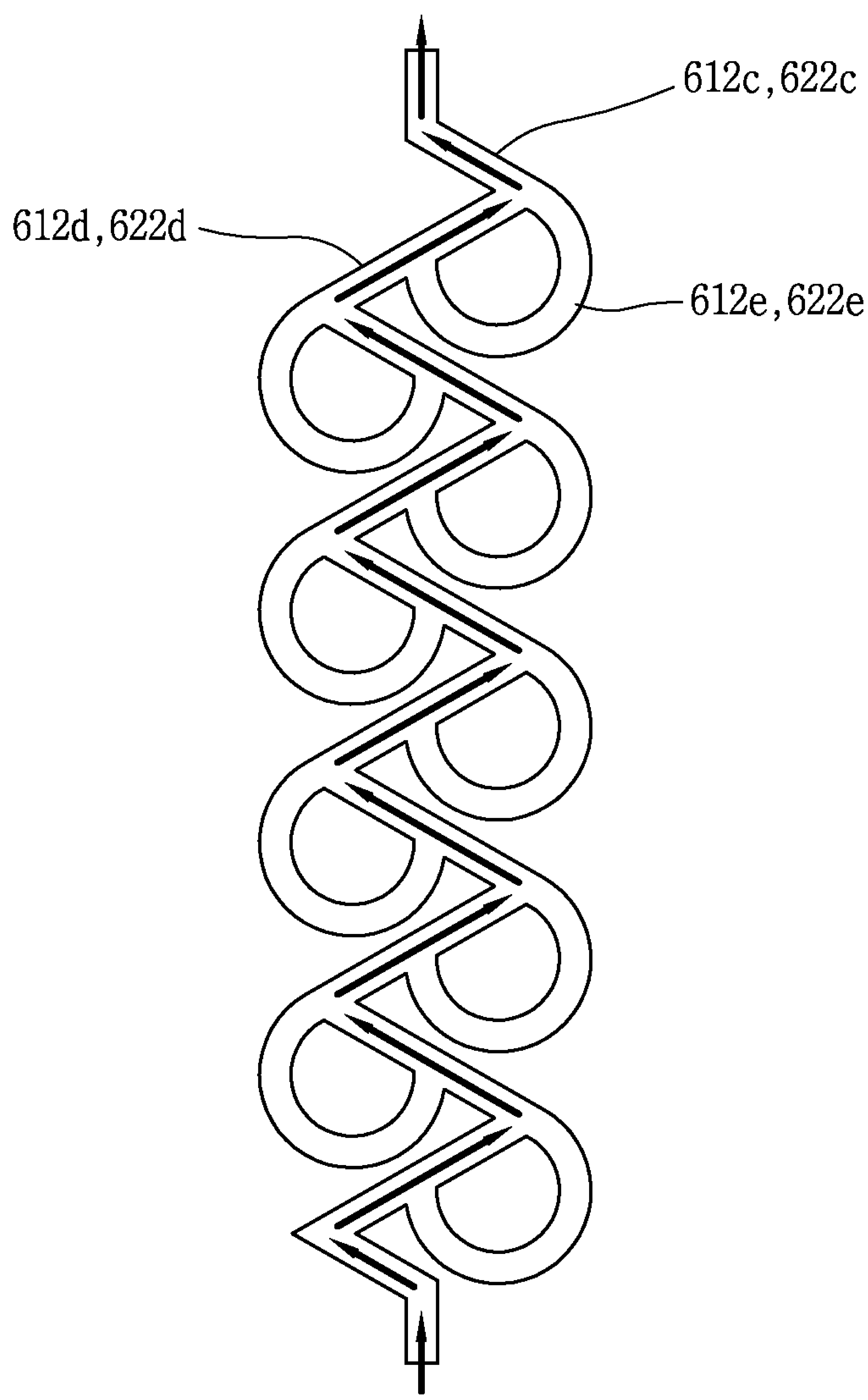
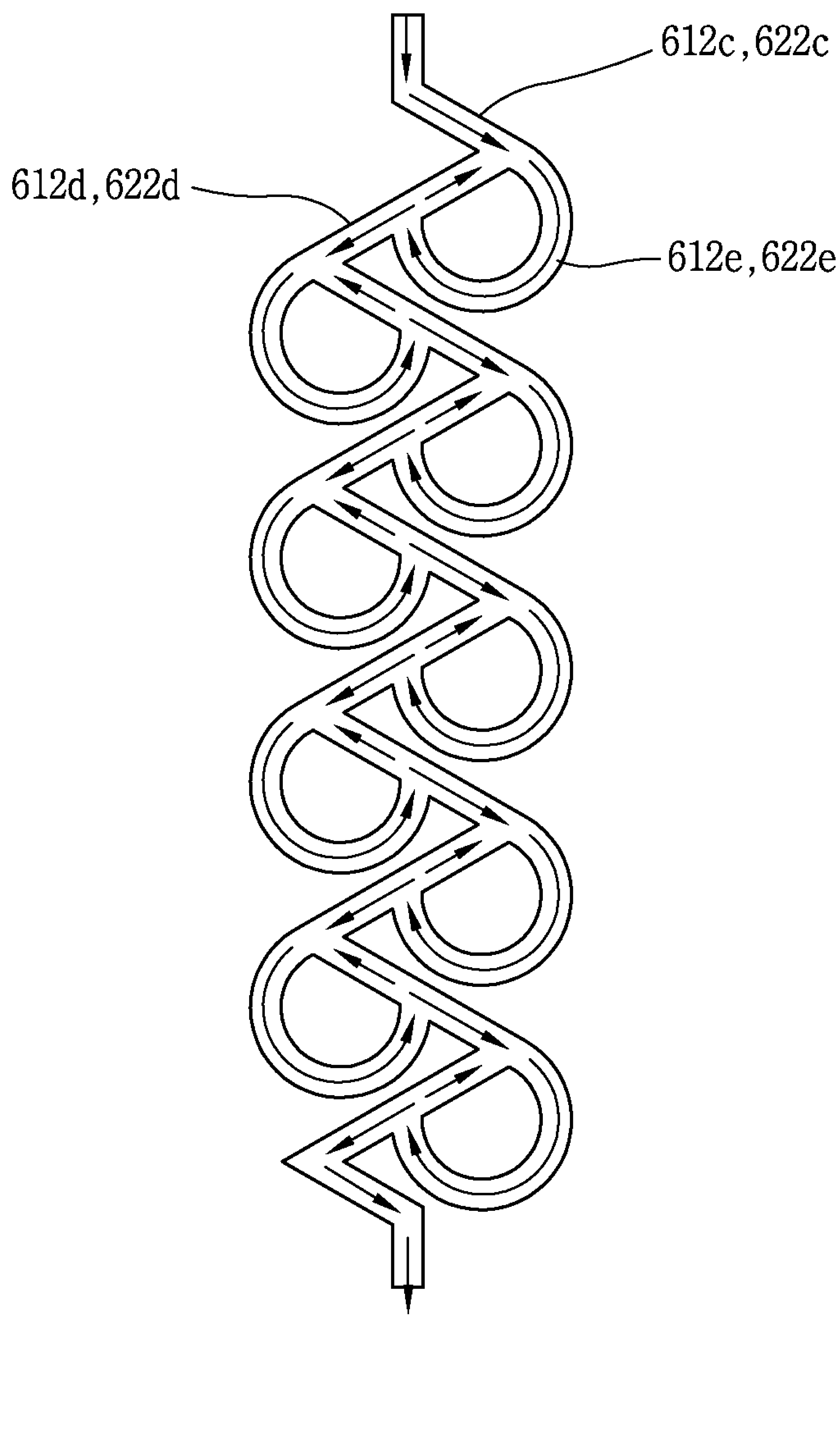


FIG. 20



HEAT EXCHANGER FOR STEAM GENERATOR AND STEAM GENERATOR COMPRISING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the national phase of PCT application PCT/KR2014/009118 having an international filing date of 29 Sep. 2014, which claims the benefit of earlier filing date and right of priority to Korean Application No. 10-2013-0124182, filed on 17 Oct. 2013, the contents of which are incorporated by reference herein in their entirety.

TECHNICAL FIELD

These embodiments relate to a technology for utilizing a printed circuit heat exchanger, a plate type heat exchanger or the like as a steam generator for stably producing steam, namely, relates to a printed circuit steam generator or a plate type steam generator.

BACKGROUND ART

A printed circuit heat exchanger has been developed by the Heatric Ltd. in UK, and very variously used in general industrial fields. The printed circuit heat exchanger is a heat exchanger having a structure in which welding between plates of the heat exchanger is avoided using a dense arrangement of channels by a photo-chemical etching technique and diffusion bonding. Accordingly, the printed circuit heat exchanger is applicable to high-temperature and high-pressure environments and has a high-density and excellent heat exchange performance. The advantages of the printed circuit heat exchanger, such as durability against the high-temperature and high-pressure environments, the high-density and the excellent heat exchange efficiency, extend an application range of the printed circuit heat exchanger to various fields, such as an evaporator, a condenser, a cooler, a radiator, a heat exchanger, a reactor, and the like, involved in an air conditioning, a fuel cell, a vehicle, a chemical process, a medical instrument, atomic energy, a nuclear power plant, a communication device, a very low temperature environment and the like.

The plate type heat exchanger is widely applied in industrial fields over one hundred years. The plate type heat exchanger is generally configured such that plates are pressed out to form channels and then coupled using gaskets or by typical molding or brazing. Accordingly, the plate type heat exchanger is similar to the printed circuit heat exchanger in view of an application field, but is more widely used under a low-pressure environment. Heat exchange efficiency of the plate type heat exchanger is lower than that of the printed circuit heat exchanger but higher than that of a shell and tube heat exchanger. Also, the plate type heat exchanger is manufactured through more simplified processes than the printed circuit heat exchanger.

However, in the applications involving two phase flow such as evaporators, the printed circuit and plate type heat exchangers have been used within limited operating conditions. The printed circuit heat exchanger or plate type heat exchanger has not been widely used as a steam generator, due to flow instabilities in channels, although it exhibits much higher heat transfer efficiency than other types of heat exchangers, such as the shell and tube type heat exchanger and the like.

Therefore, a heat exchanger which is capable of generating steam stably in various operation ranges as well as solving flow instabilities in flow channels may be taken into account.

DISCLOSURE OF THE INVENTION

Therefore, an aspect of the detailed description is to provide a heat exchanger capable of being used as a steam generator.

Another aspect of the detailed description is to provide a heat exchanger capable of generating steam more stably with an improved structure.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided a heat exchanger for a steam generator, the heat exchanger including a plate, and channels formed on the plate, wherein each of the channels includes a primary heat transmission section including a bent or curved flow path to extend longer than a distance between one side and another side, and a flow resistance section formed having a smaller width than the width of the channels formed on the primary heat transmission section, and connected to one side of the primary heat transmission section in a manner of having a bent or curved flow path to extend longer than a distance between an inlet and an outlet.

In accordance with one embodiment of the present invention, the heat exchanger may further include a flow path expanding section formed between the flow resistance section and the primary heat transmission section in a manner of having a gradually increasing width.

In accordance with one embodiment of the present invention, the flow resistance section may further include a bent or curved flow path for an increased flow resistance of the flow resistance section.

In accordance with one embodiment of the present invention, the flow resistance section may include first parts extending in a first direction as a direction connecting the inlet and the outlet to each other, and second parts extending in a second direction intersecting with the first direction. The first and second parts may be formed in an alternating manner.

In accordance with one embodiment of the present invention, the flow resistance section may further include a flow path region of sudden expansion or sudden contraction for an increased flow resistance of the flow resistance section.

In accordance with one embodiment of the present invention, one of the first and second parts may be connected to an edge of the other.

In accordance with one embodiment of the present invention, one of the first and second parts may be connected to a portion between both ends of the other.

In accordance with one embodiment of the present invention, the flow resistance section may be configured such that a forward path coming from the inlet toward the outlet has smaller flow resistance than that of a backward path coming from the outlet toward the inlet.

In accordance with one embodiment of the present invention, the flow resistance section may include first and second tilt portions connecting the inlet and the outlet, and a bypass portion formed in a manner that the backward path has greater flow resistance.

In accordance with one embodiment of the present invention, the bypass portion may be configured to extend from one end of one of the tilt portions to a portion between both ends of the other tilt portion so as to be getting away from the outlet.

In accordance with one embodiment of the present invention, the primary heat transmission section may include a first area in which fluid in a liquid state exists, a second area in which fluid in liquid and gaseous states exists, and a third area in which fluid in a gaseous state exists. At least one of channels of the first to third areas may be connected in a communicating manner.

In accordance with one embodiment of the present invention, the heat exchanger may further include a common header connected to inlets of the flow resistance section.

A heat exchanger for a steam generator according to another embodiment of the present invention, to achieve these and other advantages may include first to third plates overlaid on one another, and channels formed on the plates, respectively, wherein each of the channels includes a primary heat transmission section having a bent or curved flow path to extend longer than a distance between one side and another side, wherein the second plate includes a flow resistance section that is formed having a smaller width than the width of the channels of the primary heat transmission section, and connected to one side of the primary heat transmission section in a manner of having a bent or curved flow path to extend longer than a distance between an inlet and an outlet.

In accordance with one embodiment of the present invention, a first fluid may be introduced and discharged through the channels of the first plate, and a second fluid may be introduced and discharged through the channels of the second and third plates.

In accordance with one embodiment of the present invention, in the overlaid state of the second and third plates, the primary heat transmission section of the third plate may form an upper portion of a second channel, the primary heat transmission section of the second plate may form a lower portion of the second channel, and the first plate may form a channel with at least one plate.

In accordance with one embodiment of the present invention, the second plate may further include a lower flow path expanding section formed between the flow resistance section and the primary heat transmission section in a manner of having a gradually increasing width.

In accordance with one embodiment of the present invention, the third plate may further include an upper flow path expanding section formed at a position corresponding to the lower flow path expanding section.

In accordance with one embodiment of the present invention, the flow resistance section may further include a bent or curved flow path for an increased flow resistance of the flow resistance section.

In accordance with one embodiment of the present invention, the flow resistance section may include first parts extending in a first direction as a direction connecting the inlet and the outlet to each other, and second parts extending in a second direction intersecting with the first direction. The first and second parts may be formed in an alternating manner.

In accordance with one embodiment of the present invention, the flow resistance section may further include a flow path region of sudden expansion or sudden contraction, in order to increase flow resistance of the flow resistance section.

In accordance with one embodiment of the present invention, one of the first and second parts may be connected to an edge of the other.

In accordance with one embodiment of the present invention, one of the first and second parts may be connected to a portion between both ends of the other.

In accordance with one embodiment of the present invention, the flow resistance section may be configured such that a forward path coming from the inlet toward the outlet has smaller flow resistance than that of a backward path coming from the outlet toward the inlet.

In accordance with one embodiment of the present invention, the flow resistance section may include first and second tilt portions connecting the inlet and the outlet, and a bypass portion formed in a manner that the backward path has greater flow resistance.

In accordance with one embodiment of the present invention, the bypass portion may be configured to extend from one end of one of the tilt portions to a portion between both ends of the other tilt portion so as to be getting away from the outlet.

ADVANTAGEOUS EFFECT

In accordance with the detailed description, a heat exchanger for a steam generator according to at least one embodiment of the present invention with the configuration can increase flow resistance in a flow resistance section, which may enable more stable production of steam and therefore expand a lifespan of the heat exchanger for the steam generator.

Also, a wider flow path area can be applied to the steam generator, which may result in reducing contamination of the flow path.

And, with the use of simply switching flow paths, the heat exchanger for the steam generator according to the present invention can be applied to the related art heat exchanger for the steam generator. Also, the heat exchanger for the steam generator can be fabricated into a more compact size, and welded portions can be removed from primary heat transmission section.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a conceptual view of channels formed on a second plate of the related art heat exchanger.

FIG. **2** is a conceptual view of channels formed on a first plate of the related art heat exchanger.

FIGS. **3** to **7** are conceptual views of channels formed on a second plate of a heat exchanger for a steam generator in accordance with embodiments of the present invention.

FIGS. **8** to **12** are conceptual views of channels formed on a second plate of a heat exchanger for a steam generator in accordance with embodiments of the present invention.

FIGS. **13**A and **13**B are conceptual views of channels formed on a second plate of a heat exchanger for a steam generator in accordance with another embodiment of the present invention.

FIG. **14** is a conceptual view of channels formed on a third plate of a heat exchanger for a steam generator in accordance with another embodiment of the present invention.

FIG. **15** is a conceptual view of channels formed on a second plate of a heat exchanger for a steam generator in accordance with another embodiment of the present invention.

FIG. **16** is a conceptual view of channels formed on a first plate of a heat exchanger for a steam generator in accordance with another embodiment of the present invention.

FIG. **17** is a cross-sectional view, taken along the line IV-IV of FIGS. **14** to **16**.

FIG. **18** is a cross-sectional view, taken along the line V-V of FIGS. **14** to **16**.

FIGS. **19** and **20** are conceptual views illustrating a flow of fluid in a flow resistance section illustrated in FIGS. **7** and **12**, respectively.

MODES FOR CARRYING OUT THE PREFERRED EMBODIMENTS

Description will now be given in detail of a heat exchanger for a steam generator according to exemplary embodiments disclosed herein, with reference to the accompanying drawings. A suffix "module" or "unit" used for constituent elements disclosed in the following description is merely intended for easy description of the specification, and the suffix itself does not give any special meaning or function. For the sake of brief description with reference to the drawings, the same or equivalent components will be provided with the same reference numbers, and description thereof will not be repeated. A singular representation may include a plural representation unless it represents a definitely different meaning from the context.

A steam generator turns (converts) secondary water into steam using heat of primary water, supplies the steam to a turbine, and rotates the turbine using the supplied steam to generate electric power. A plurality of heat exchangers is disposed in the steam generator. And, when a first fluid passes through a first plate of a heat exchanger, a second fluid passing through a second plate is converted into steam by heat transferred to the second plate which is disposed adjacent to the first plate.

FIG. **1** is a conceptual view of channels C formed on a second plate **120** of the related art heat exchanger, and FIG. **2** is a conceptual view of channels C formed on a first plate of the related art heat exchanger.

As illustrated in FIGS. **1** and **2**, when a first coolant flows through the channels C formed on the first plate **110**, heat is transferred to the second plate **120**. The transferred heat may heat a second coolant which flows along the second plate **120**, thereby producing steam.

In this process, generally in heat exchangers involving two phase flow within flow channels, flow instabilities may occur if the flow path (d**1** in FIG. **1**) is used, due to the pressure wave propagation, which stems from a rapid increase in volume and decrease in density by steam generation. Accordingly, pressure waves are propagated forward and backward in a flow path direction. The pressure drop difference which is initiated from a discrepancy of the phase change location causes an unstable flow, and this increases the flow instability. Especially, for a steam generator having a plurality of flow channels connected to a common header, the instability becomes more stronger by the feedback effect of the phase change mismatch between the multi-channels (parallel channel oscillation), and a function as a steam generator could be lost. This is specifically an important issue for the steam generators with a wide range operation mode such as a startup and a low level power operation.

To reduce such effects a shell and tube type steam generator with a wide general operation range applies an orifice with high flow resistance at the inlet of the secondary tube.

As illustrated in FIG. **1**, the related art technology (d**2** to d**4**) simply reducing a flow path area may cause problems, such as flow path fouling, clogging, blocking and the like, and thus may be restricted from being applied to applications requiring for a long-term lifespan, such as a nuclear power environment. In the present invention, contamination of a flow path refers to an effect that various types of impurities, which are accumulated due to a long-term use of the steam generator, reduce or block a cross section of a flow path. As a result, this affects a flow rate of water. This problem may be accelerated as an inlet flow path cross section is more reduced.

The first plate and the second plate may be installed at positions where inlets or outlets thereof do not overlap each other, and thus the present invention may not be limited to the configuration of the printed circuit flow path as illustrated in FIG. **1** or **2**.

Hereinafter, a heat exchanger or a heat exchanger for a steam generator disclosed herein, unless especially mentioned, generally refers to the general plate type and printed circuit heat exchangers, and also even a case of employing a different processing or bonding method for plates.

FIGS. **3** to **7** are conceptual views of channels formed on a second plate of a heat exchanger for a steam generator in accordance with embodiments of the present invention.

While a second fluid flows through the second plate **220**, **320**, **420**, **520**, **620**, phase transition from liquid to gas occurs, thereby generating steam. The second plate **220**, **320**, **420**, **520**, **620** may include a plurality of channels C, which may have widths in the range of one meter (m) to several millimeters (mm).

Each of the channels C may divided into a primary heat transmission section **221**, **321**, **421**, **521**, **621** and a flow resistance section **222**, **322**, **422**, **522**, **622**. The channel C of the primary heat transmission section **221**, **321**, **421**, **521**, **621** may be bent so as to extend longer than a distance between one side **221***a*, **321***a*, **421***a*, **521***a*, **621***a* and another side **221***b*, **321***b*, **421***b*, **521***b*, **621***b* (a length at which one side **221***a*, **321***a*, **421***a*, **521***a*, **621***a* and another side **221***b*, **321***b*, **421***b*, **521***b*, **621***b* are connected in a straight line). This may extend the length of each channel C than the straightly-connected length, which may greatly increase a heat exchange area and improve heat exchanger efficiency accordingly. The embodiment disclosed herein merely illustrates the bent shape, but the present invention may not be necessarily limited to the flow path in the bent shape because a similar effect can be obtained even in case of using a curved flow path.

Each of the channels of the flow resistance section **222**, **322**, **422**, **522**, **622** may have a width smaller than the width of the channel formed on the primary heat transmission section **221**, **321**, **421**, **521**, **621**, and may be bent so as to extend longer than a distance between one side **222***a*, **322***a*, **422***a*, **522***a*, **622***a* and another side **222***b*, **322***b*, **422***b*, **522***b*, **622***b* (a length at which one side **222***a*, **322***a*, **422***a*, **522***a*, **622***a* and another side **222***b*, **322***b*, **422***b*, **522***b*, **622***b* are connected in a straight line). The flow resistance section **222**, **322**, **422**, **522**, **622** may be connected to one side corresponding to an inlet of the primary heat transmission section **221**, **321**, **421**, **521**, **621**. The flow resistance section **222**, **322**, **422**, **522**, **622** may be provided with longer and narrower channels at the inlet area, resulting in greater flow resistance and thus reduced flow instability in each channel within a wide operation range. Accordingly, the steam generator can operate in a stable state. The embodiment disclosed herein merely illustrates the bent shape, but the present invention may not be necessarily limited to the bent shape because a similar effect can be obtained even in case of using a curved flow path.

A flow path expanding section **223**, **323**, **423**, **523**, **623** may be formed between the flow resistance section **222**, **322**, **422**, **522**, **622** and the primary heat transmission section **221**,

321, **421**, **521**, **621**. The flow path expanding section **223**, **323**, **423**, **523**, **623** may have a width which gradually increases, thereby preventing a drastic change in the coolant flow.

FIGS. **3** and **4** illustrate exemplary configurations according to the present invention which employ flow path structures reducing a flow path area and increasing a flow path length, respectively, in order to increase flow resistance of the flow resistance sections **222**, **322**, but the present invention may not be necessarily limited to these configurations.

Referring to FIG. **3**, the flow resistance section **222** includes first (primary) parts **222***c* and second (secondary) parts **222***d*. The first parts **222***c* are portions extending in a first (primary) direction which is a direction connecting an inlet and an outlet, and the second parts **222***d* are portions extending in a second (secondary) direction which intersects with the first direction. The first parts **222***c* and the second parts **222***d* may be formed in an alternating manner. One of the first and second parts **222***c* and **222***d* may be connected to an edge of the other.

Referring to FIG. **4**, the flow resistance section **322** includes first tilt portions **322***c* and second tilt portions **322***d*. The first tilt portion **322***c* and the second tilt portion **322***d* may be connected with each other at one end.

FIGS. **5** and **6** illustrate exemplary configurations according to the present invention which employ different flow path structures from those illustrated in FIGS. **3** and **4**, respectively, in order to increase flow resistance of the flow resistance sections **422** and **522**, but the present invention may not be necessarily limited to this configuration.

Referring to FIG. **5**, the flow resistance section **422** includes first parts **422***c* and second parts **422***d*. The first parts **422***c* are portions extending in a first direction which is a direction connecting an inlet and an outlet, and the second parts **422***d* are portions extending in a second direction that intersects with the first direction. The first parts **422***c* and the second parts **422***d* may be formed in an alternating manner. One of the first and second parts **422***c* and **422***d* may be connected to an edge of the other. The first parts **422***c* and the second parts **422***d* have different lengths and more bent portions, respectively, unlike those illustrated in FIG. **3**. This may increase the flow resistance further.

Referring to FIG. **6**, the flow resistance section **522** includes first parts **522***c* and second parts **522***d*. The first parts **522***c* are portions extending in a first direction which is a direction connecting an inlet and an outlet, and the second parts **522***d* are portions extending in a second direction that intersects with the first direction. The first parts **522***c* and the second parts **522***d* may be formed in an alternating manner. One of the first and second parts **522***c* and **522***d* is connected to a portion between both ends of the other. The first and second parts **522***c* and **522***d*, unlike those illustrated in FIG. **3**, may have different lengths, respectively, and also include a flow path region of sudden expansion or sudden contraction, so as to have a shape causing greater flow resistance. This may result in an increased the flow resistance.

FIG. **7** illustrates an exemplary configuration according to the present invention in which different flow path structures are applied in a forward direction and a backward direction in order to increase backward flow resistance of the flow resistance section **622**, but the present invention may not be limited to this configuration.

Referring to FIG. **7**, the flow resistance section **622** includes first tilt portions **622***c* and second tilt portions **622***d*. Here, the flow resistance section **622** is configured such that a forward path coming from an inlet to an outlet has smaller flow resistance than a backward path coming from the outlet to the inlet. Accordingly, the backward flow resistance may become greater than the forward flow resistance.

To achieve this, a bypass portion **622***e* is provided in which the backward path has greater flow resistance. The bypass portion **622***e* connects an edge of one of the tilt portions to a portion between both ends of the other tilt portion so as to be getting away from an outlet.

FIGS. **8** to **12** are conceptual views of channels formed on a second plate of a heat exchanger for a steam generator in accordance in accordance with embodiments of the present invention. In such case, the channels may be formed on the first plate by switching a flowing direction to be opposite to the flowing direction of FIG. **1** (d**1**).

The second plate **1220**, **1320**, **1420**, **1520**, **1620** may include a plurality of channels C, which have widths in the range of 1 m to several millimeters (mm).

Each of the channels C formed on the second plate **1220**, **1320**, **1420**, **1520**, **1620** may be divided into a primary heat transmission section **1221**, **1321**, **1421**, **1521**, **1621** and a flow resistance section **1222**, **1322**, **1422**, **1522**, **1622**. Each of the channels C of the primary heat transmission sections **1221**, **1321**, **1421**, **1521**, **1621** may be bent so as to extend longer than a distance between one side **1221***a*, **1321***a*, **1421***a*, **1521***a*, **1621***a* and another side **1221***b*, **1321***b*, **1421***b*, **1521***b*, **1621***b* (a length at which one side **1221***a*, **1321***a*, **1421***a*, **1521***a*, **1621***a* and another side **1221***b*, **1321***b*, **1421***b*, **1521***b*, **1621***b* are connected in a straight line). This may extend channel length, which may increase the heat exchange area and improve heat exchanger efficiency accordingly. The embodiment disclosed herein merely illustrates the bent shape, but the present invention may not be necessarily limited to the flow path in the bent shape because a similar effect can be obtained even in case of using a curved flow path.

Each of the channels of the flow resistance section **1222**, **1322**, **1422**, **1522**, **1622** may have a width smaller than a channel formed on the primary heat transmission section **1221**, **1321**, **1421**, **1521**, **1621**, and may be bent so as to extend longer than a distance between one side **1222***a*, **1322***a*, **1422***a*, **1522***a*, **1622***a* and another side **1222***b*, **1322***b*, **1422***b*, **1522***b*, **1622***b* (a length at which one side **1222***a*, **1322***a*, **1422***a*, **1522***a*, **1622***a* and another side **1222***b*, **1322***b*, **1422***b*, **1522***b*, **1622***b* are connected in a straight line). The flow resistance section **1222**, **1322**, **1422**, **1522**, **1622** may be connected to one side corresponding to an inlet of the primary heat transmission section **1221**, **1321**, **1421**, **1521**, **1621**. The flow resistance section **1222**, **1322**, **1422**, **1522**, **1622** may form channels, which are longer in length and smaller in width, at the inlet area of the heat exchanger. This may result in greater flow resistance and thus reduced flow instability in each channel within a wide operation range. Accordingly, the steam generator can operate in a stable state. The embodiment disclosed herein merely illustrates the bent shape, but the present invention may not be necessarily limited to the bent shape because a similar effect can be obtained even in case of using a curved flow path.

A flow path expanding section **1223**, **1323**, **1423**, **1523**, **1623** may be formed between the flow resistance section **1222**, **1322**, **1422**, **1522**, **1622** and the primary heat transmission section **1221**, **1321**, **1421**, **1521**, **1621**. The flow path expanding section **1223**, **1323**, **1423**, **1523**, **1623** may have a width which gradually increases, thereby preventing a drastic change in the coolant flow.

Also, a common header **1224**, **1324**, **1424**, **1524**, **1624** may be formed at an inlet of the flow resistance section **1222**, **1322**, **1422**, **1522**, **1622**. A second fluid supplied through the common header **1224**, **1324**, **1424**, **1524**, **1624** is distributed into the channels C of the second plate **1220**, **1320**, **1420**, **1520**, **1620**, respectively.

FIGS. **8** and **9** illustrate exemplary configurations according to the present invention employing flow path structures of reducing a flow path area and increasing a flow path length, in order to increase flow resistance of the flow resistance sections **1222**, **1322**, but the present invention may not be necessarily limited to these configurations.

Referring to FIG. **8**, the flow resistance section **1222** includes first parts **1222***c* and second parts **1222***d*. The first parts **1222***c* are portions extending in a first direction which is a direction connecting an inlet and an outlet, and the second parts **1222***d* are portions extending in a second direction which intersects with the first direction. The first parts **1222***c* and the second parts **1222***d* may be formed in an alternating manner. One of the first and second parts **1222***c* and **1222***d* may be connected to an edge of the other.

Referring to FIG. **9**, the flow resistance section **1322** includes first tilt portions **1322***c* and second tilt portions **1322***d*. The first tilt portion **1322***c* and the second tilt portion **1322***d* may be connected with each other at one end.

FIGS. **10** and **11** illustrate exemplary configurations according to the present invention which employs different flow path structures from those illustrated in FIGS. **8** and **9**, in order to increase flow resistance of the flow resistance sections **1422** and **1522**, but the present invention may not be necessarily limited to this configuration.

Referring to FIG. **10**, the flow resistance section **1422** includes first parts **1422***c* and second parts **1422***d*. The first parts **1422***c* are portions extending in a first direction which is a direction connecting an inlet and an outlet, and the second parts **1422***d* are portions extending in a second direction that intersects with the first direction. The first parts **1422***c* and the second parts **1422***d* may be formed in an alternating manner. One of the first and second parts **1422***c* and **1422***d* may be connected to an edge of the other. The first and second parts **1422***c* and **1422***d*, unlike those illustrated in FIG. **3**, have different shapes and more bent portions, respectively. This may increase the flow resistance further.

Referring to FIG. **11**, the flow resistance section **1522** includes first parts **1522***c* and second parts **1522***d*. The first parts **522***c* are portions extending in a first direction which is a direction connecting an inlet and an outlet, and the second parts **1522***d* are portions extending in a second direction that intersects with the first direction. The first parts **1522***c* and the second parts **1522***d* may be formed in an alternating manner. One of the first and second parts **1522***c* and **1522***d* is connected to a portion between both side ends of the other. The first and second parts **1522***c* and **1522***d*, unlike those illustrated in FIG. **3**, may have different lengths, respectively, and also include a flow path region of sudden expansion or sudden contraction, so as to have a shape causing greater flow resistance. This may result in an increased the flow resistance.

FIG. **12** illustrates an exemplary configuration according to the present invention which employs different flow path structures in a forward direction and a backward direction in order to increase backward flow resistance of the flow resistance section **1622**, but the present invention may not be limited to this configuration.

Referring to FIG. **12**, the flow resistance section **622** includes first tilt portions **1622***c* and second tilt portions **1622***d*. Here, the flow resistance section **1622** is configured such that a forward path coming from an inlet to an outlet has smaller flow resistance than a backward path coming from the outlet to the inlet. Accordingly, the backward flow resistance may be greater than the forward flow resistance.

To achieve this, a bypass portion **1622***e* is provided in which the backward path has greater flow resistance. The bypass portion **1622***e* connects one end of one of the tilt portions to a portion between both ends of the other tilt portion so as to be getting away from an outlet.

FIGS. **13**A and **13**B are conceptual views of channels C formed on a second plate of a heat exchanger for a steam generator in accordance in another exemplary embodiment of the present invention.

Referring to FIG. **13**A, each of the channels C may be divided into a primary heat transmission section **221** and a flow resistance section **222**. Each of the channels C of the primary heat transmission section **221** may be bent so as to extend longer than a distance between one side **221***a* and another side **221***b* (a length at which one side **221***a* and another side **221***b* are connected in a straight line). This may extend the length of each channel C than the straightly-connected length, which may increase the heat exchange area and improve heat exchanger efficiency accordingly.

The embodiment disclosed herein merely illustrates the bent shape, but the present invention may not be necessarily limited to the flow path in the bent shape because a similar effect can be obtained even in case of using a curved flow path.

The primary heat transmission section **221** may be divided into a first area R**1** in which fluid in a liquid state exists, a second area R**2** in which fluid in liquid and gaseous states exists, and a third area R**3** in which fluid in a gaseous state exists.

The channels C of the second area R**2** or the third area R**3** may communicate with each other. In more detail, the channels C of the second area R**2** adjacent to the third area R**3** may communicate with each other. This may more facilitate the fluid in the gaseous state to flow along the channels C.

Each of the channels of the flow resistance section **222** may be configured to be narrower in width than the channel formed on the primary heat transmission section **221**, and configured into a bent form so as to extend longer than a distance between an inlet **222***a* and an outlet **222***b* (a length at which an inlet **222***a* and an outlet **222***b* are connected in a straight line). The flow resistance section **222** may be connected to one side corresponding to an inlet of the primary heat transmission section **221**. The flow resistance section **222** may form channels with a longer length and a smaller width at an inlet area of the heat exchanger, to generate great flow resistance, thereby reducing flow instability in each channel within a wide operation range. This may allow for a stable operation of the steam generator. This embodiment merely illustrates the bent shape, but the present invention may not be limited to the bent shape because a similar effect can be obtained even in case of using a curved flow path.

A flow path expanding section **223** may be formed between the flow resistance section **222** and the primary heat transmission section **221**. The flow path expanding section **223** may be formed to have a gradually increasing width, so as to prevent the drastic change in a flow of coolant.

Still referring to FIG. **13**A, the flow resistance section **222** includes first parts **212***c* and second parts **212***d*. The first parts **212***c* are portions extending in the first direction which is a direction connecting an inlet and an outlet, and the second parts **212***d* are portions extending in a second direction which intersects with the first direction. The first parts **212***c* and the second parts **212***d* may be formed in an alternating manner. One of the first and second parts **212***c* and **212***d* may be connected to an edge of the other. FIG. **13**A illustrates an exemplary configuration in which some flow paths communicate with each other, but the present invention may not be necessarily limited to such configurations.

Also, referring to FIG. **13**B, when most of the channels C of the primary heat transmission section **221** are configured to communicate with one another, the primary heat transmission section **221** may exhibit similar characteristics to an operation of a shell side of a shell and tube type heat exchanger. Therefore, the flow resistance section **222** serves as an economizer which enables a uniform distribution of a flow rate and improves heat transger characteristics. FIG. **13**B illustrates an exemplary configuration in which most channels of the primary heat transmission section **221** communicate with one another, but the present invention may not be necessarily limited to such configurations.

FIG. **14** is a conceptual view of channels C formed on a third plate of a heat exchanger for a steam generator in accordance with another embodiment of the present invention, FIG. **15** is a conceptual view of channels C formed on a second plate of a heat exchanger for a steam generator in accordance with another embodiment of the present invention, and FIG. **16** is a conceptual view of channels C formed on the first plate of a heat exchanger for a steam generator in accordance with another embodiment of the present invention.

And, FIG. **17** is a cross-sectional view, taken along the line IV-IV of FIGS. **14** to **16**, and FIG. **18** is a cross-sectional view, taken along the line V-V of FIGS. **14** to **16**.

As illustrated in FIGS. **14** to **18**, the first to third plates **710**, **720** and **730** are arranged in an overlaying manner. In more detail, the second plate **720** is disposed on the first plate **710**, and the third plate **730** may be disposed on the second plate **720**. Although not illustrated, at least one another plate may be disposed on the third plate **730**, and a second fluid may flow along the plate disposed on the third plate **730**.

While flowing along the first plate **710**, a first fluid transfers heat to a second fluid which flows along the second and third plates **720** and **730**. Phase transition of the second fluid from liquid to gas may occur due to the heat from the first fluid.

In this instance, the second and third plates **720** and **730** may form one channel at a predetermined section. That is, as illustrated in FIG. **18**, when the second plate **720** forms a lower portion of a channel, the third plate may form an upper portion of the channel. Here, the predetermined section may correspond to the primary heat transmission sections **721** and **731** of the channels C formed on the second and third plates **720** and **730**, respectively.

Referring back to FIG. **15**, each of the channels C of the second plate **720** may be divided into a primary heat transmission section **721** and a flow resistance section **722**. The channel C of the primary heat transmission section **721** may be configured into a bent form so as to extend longer than a distance between one side **721***a* and another side **721***a* (a length at which one side **721***a* and another side **721***a* are connected in a straight line). This may extend the length of the channel C than the straightly-connected length, which may increase the heat exchange area and improve heat exchanger efficiency accordingly. The embodiment disclosed here has illustrated the bent shape, but the present invention may not be necessarily limited to the flow path in the bent shape because a similar effect can be obtained even in case of using a curved flow path.

Each of the channels C of the flow resistance section **722** is configured to be narrower in width than the channel formed on the primary heat transmission section **721**, and configured into a bent form so as to extend longer than a distance between an inlet **722***a* and an outlet **722***b* (a length at which an inlet **722***a* and an outlet **722***b* are connected in a straight line). The flow resistance section **722** may be connected to one side corresponding to an inlet of the primary heat transmission section **721**. The flow resistance section **722** may form channels with a longer length and a smaller width at an inlet area of the heat exchanger, to generate great flow resistance, thereby reducing flow instability in each channel within a wide operation range. This may allow for a stable operation of the steam generator. This embodiment merely illustrates the bent shape, but the present invention may not be limited to the bent shape because a similar effect can be obtained even in case of using a curved flow path.

A flow path expanding section **723** may be formed between the flow resistance section **722** and the primary heat transmission section **721**. The flow path expanding section **723** may have a width which gradually increases, so as to prevent the drastic change in a flow of coolant.

Referring back to FIG. **14**, each of the channels C of the third plate **730** may include only a primary heat transmission section **731** and a flow path expanding section **733**, without a flow resistance section. This results from that the second and third plates **720** and **730** form the lower and upper portions of the channel, respectively. The flow resistance section **722** of the second plate **720** may be connected to the flow path expanding sections **723** and **733** of the second and third plates **720** and **730**.

Referring back to FIG. **16**, each of the channels formed on the first plate **710** includes the primary heat transmission section **711**. Each channel of the primary heat transmission section **711** may be bent to extend longer than a distance between one side **711***a* and another side **711***b* (a length at which one side **711***a* and another side **711***b* are connected in a straight line). This may extend the length of each channel C than the straightly-connected length, which may increase a heat exchange area and improve heat exchanger efficiency accordingly. The embodiment disclosed here has illustrated the bent shape, but the present invention may not be necessarily limited to a flow path in a bent shape because a similar effect can be obtained even in case of using a curved flow path.

The plates illustrated in FIGS. **14** to **16** merely illustrate the embodiments constructing the plates of the heat exchanger. That is, as aforementioned with reference to FIGS. **3** to **13**, a flow resistance section, a flow path expanding section or a common header may be formed on a plate according to design conditions of the heat exchanger.

FIGS. **19** and **20** are conceptual views illustrating fluid flows inside a flow resistance section illustrated in FIGS. **7** and **12**, respectively. As illustrated, the flow resistance section **612**, **622** includes first tilt portions **612***c*, **622***c* and second tilt portions **612***d*, **622***d*. Here, the flow resistance section **612**, **622** is configured such that a forward path coming from an inlet to an outlet exhibits smaller flow resistance than a backward path coming from the outlet to the inlet and a forward flow exhibits a smoother change than a backward flow. Accordingly, the backward flow resistance may be greater than the forward flow resistance.

To achieve this, bypass portion **612***e*, **622***e* with great flow resistances is provided, which results from extended backward path and interference between flowing directions intersecting with each. The bypass portion **612***e*, **622***e* is configured in a manner that connects one end of one of the tilt portions to a portion between both ends of the other tilt portion so as to be getting away from an outlet.

Fluid flows along the first tilt portion **612***c*, **622***c* and the second tilt portion **612***d*, **622***d* in the forward direction, whereas flowing along the first tilt portion **612***c*, **622***c* and then flowing toward a middle point of the second tilt portion **612***d*, **622***d* via the bypass portion **612***e*, **622***e* in the backward direction. Accordingly, the backward path may become longer than the forward path and flowing directions of the backward and forward paths may cross each other to cause interference therebetween. This may result in more increased backward flow resistance than forward flow resistance.

The aforementioned heat exchanger for the steam generator may not be necessarily limited to the configurations and methods of the foregoing embodiments, but a part or all of the embodiments can be selectively combined to derive many variations.

INDUSTRIAL AVAILABILITY

The heat exchanger for the steam generator according to the present invention may not be limited applied to the configurations and methods of the aforementioned embodiments, but a part or all of the embodiments can be selectively combined to derive various modifications.

The invention claimed is:

1. A heat exchanger for a steam generator, the heat exchanger comprising:
- a plate; and
- channels formed on the plate,
- wherein each of the channels comprises:
- a primary heat transmission section including a bent or curved flow path to extend longer than a distance between one side and another side; and
- a flow resistance section formed having a smaller width than the width of the channels formed on the primary heat transmission section, and connected to one side of the primary heat transmission section in a manner of having a bent or curved flow path to extend longer than a distance between an inlet and an outlet,
- wherein each primary heat transmission section includes a respective channel and the respective channels are configured to communicate with one another, and
- each of the channels includes a flow path expanding section formed between the flow resistance section and the primary heat transmission section in a manner of having a gradually increasing width.

2. The heat exchanger of claim **1**, wherein the flow resistance section comprises:
- first parts extending in a first direction as a direction connecting the inlet and the outlet to each other; and
- second parts extending in a second direction intersecting with the first direction,
- wherein the first and second parts are formed in an alternating manner.

3. The heat exchanger of claim **1**, wherein the flow resistance section further has a shape for an increased flow resistance of the flow resistance section.

4. The heat exchanger of claim **3**, wherein the shape for increasing the flow resistance of the flow resistance section further has a bent or curved flow path.

5. The heat exchanger of claim **3**, wherein the shape for increasing the flow resistance of the flow resistance section further has a flow path region of sudden expansion or sudden contraction.

6. The heat exchanger of claim **3**, wherein the flow resistance section is configured such that a forward path coming from the inlet toward the outlet has different flow resistance from that of a backward path coming from the outlet toward the inlet.

7. The heat exchanger of claim **1**, wherein the primary heat transmission section comprises:
- a first area in which fluid in a liquid state exists;
- a second area in which fluid in liquid and gaseous states exists; and
- a third area in which fluid in a gaseous state exists,
- wherein at least one of channels of the first to third areas is connected in a communicating manner.

8. The heat exchanger of claim **7**, wherein the flow resistance section serves as an economizer that uniformizes a flow rate of an inlet of the heat exchanger and increases heat exchange efficiency at a single-phase area.

9. The heat exchanger of claim **1**, wherein the plate is provided with channels formed by a photo-chemical etching method or in a pressing manner.

10. A steam generator comprising the heat exchanger according to claim **1**.

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